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ABSTRACTS

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Systematic Bias and Model Independence in Land Surface Models

Primary Author: Abramowitz, Gab

Systematic Bias and Model Independence in Land Surface Models

Gab Abramowitz, Macquarie University/CSIRO Marine and Atmospheric Research

This presentation will discuss a neural network based technique for identifying and correcting systematic bias in land surface model(LSM) flux predictions. As a result of the correction, per time-step RMSE in latent heat, sensible heat and NEE is reduced by as much as 45%, translating to reductions of as much as 90% on annual time scales when tested against a range of Fluxnet sites. Three LSMs are considered. By manipulating the relationship between neural network training and testing sets, we show that LSM bias is relatively independent of vegetation characteristics, and further that the nature of bias is shared between some LSMs. This type of result has the potential to reveal which areas of model parameterisation are weak as well as to provide a metric for model independence. The implications for parameter estimation, model validation and model independence in ensemble simulations will be discussed.

Improvements in ENSO Simulation in the AR4 Models (Compared to CMIP2)

Primary Author: AchutaRao, Krishna

Improvements in ENSO Simulation in the AR4 Models (Compared to CMIP2)

Krishna M. AchutaRao and Kenneth R. Sperber

Maintaining a multi-model database over a generation or more of model development provides an important framework for assessing model improvement. Using control integrations, we compare the simulation of the El Nino/Southern Oscillation (ENSO), and its extratropical impact, in models developed for the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report with models developed in the late 1990s [the so-called Coupled Model Intercomparison Project-2 (CMIP2) models]. The IPCC models tend to be more realistic in representing the frequency with which ENSO occurs, and they are better at locating enhanced temperature variability over the eastern Pacific Ocean. When compared with reanalyses, the IPCC models have larger pattern correlations of tropical surface air temperature than do the CMIP2 models during the boreal winter peak phase of El Niño. However, for sea-level pressure and precipitation rate anomalies, a clear separation in performance between the two vintages of models is not as apparent. The strongest improvement occurs for the modeling groups whose CMIP2 model tended to have the lowest pattern correlations with observations. This has been checked by subsampling the multi-century IPCC simulations in a manner to be consistent with the single 80-year time segment available from CMIP2. Our results suggest that multi-century integrations may be required to statistically assess model improvement of ENSO. The quality of the El Nino precipitation composite is directly related to the fidelity of the boreal winter precipitation climatology, highlighting the importance of reducing systematic model error. Over North America distinct improvement of El Nino forced boreal winter surface air temperature, sea-level pressure, and precipitation rate anomalies to occur in the IPCC models. This improvement is directly proportional to the skill of the tropical El Nino forced precipitation anomalies.

Ocean Heat Content Variability in the Second Half of the 20th Century: Results from the IPCC AR4 Simulations

Primary Author: AchutaRao, Krishna

Ocean Heat Content Variability in the Second Half of the 20th Century: Results from the IPCC AR4 Simulations

AUTHORS: Krishna AchutaRao, Benjamin Santer, Peter Gleckler, Karl Taylor, Masayoshi Ishii, Tim Barnett, Jonathan M. Gregory, David W. Pierce, Ronald J. Stouffer, and T.M.L. Wigley

ABSTRACT:

Coupled Atmosphere-Ocean General Circulation Models (A OGCMs) are generally thought to systematically underestimate the amplitude of ocean heat content variability, particularly on decadal and longer timescales. We have recently demonstrated that subsampling model data at the locations of available observations increases the simulated variability, reducing the discrepancy between models and observations.

In the present work, we examine multiple simulations of the 20th Century climate from 13 different climate models that were carried out for the Fourth Assessment Report(AR4) of the IPCC. Many of these simulations include climate forcings such as solar variability, volcanic and anthropogenic aerosols, and stratospheric ozone loss. This enables us to compare data from these simulations directly to observational estimates of ocean temperature variation from the second half of the 20th Century. We specifically examine the role of varying observational coverage and the inclusion of volcanoes in the simulated variability of ocean temperatures.

Evaluation of the Radiative Energy Budget in Climate and NWP Models Using Satellite Data, Reanalyses and Ground-based Observations

Primary Author: Allan, Richard

Additional Authors: Anthony Slingo, Sean F. Milton, Malcolm E. Brooks

Evaluation of the Radiative Energy Budget in Climate and NWP Models Using Satellite Data, Reanalyses and Ground-based Observations

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Results from three projects are presented in which satellite and ground-based measurements of radiative fluxes and water vapor are utilised in evaluations of a suite of models including detailed radiative transfer codes, operational weather forecasting models and climate simulations.

1) The top of atmosphere radiative fluxes simulated by the Met Office global forecast model are evaluated using new data from the Geostationary Earth Radiation Budget (GERB) instrument and other data from the Meteosat-8 satellite. Large errors in the top of atmosphere energy balance arise over the Sahara, relating to poor representation of surface albedo and mineral dust aerosol. Marine stratocumulus cloud is too reflective in the model.

2) Simultaneous measurement of radiative fluxes at the surface and top of the atmosphere are presented as part of the RADAGAST project. The radiative imprint of a major dust storm during March 2006 is detailed; radiative transfer schemes underestimate the absorption of solar radiation in the dusty atmosphere.

3) Reanalysis and satellite observations are combined to evaluate the IPCC AR4 climate model simulations of the clear-sky longwave radiative energy balance and the atmospheric hydrological cycle. The influence of forecast lead-time on reanalyses quality are examined and the sensitivity of satellite clear-sky fluxes to footprint size are estimated using data from GERB/SEVIRI. There is a significant positive relationship between clear-sky longwave radiative cooling of the atmosphere and surface temperature of 3.6 to 4.6 Wm⁻²K⁻¹ over tropical ocean descent regimes in the reanalyses and satellite-based datasets. Comparison with model simulations and links with precipitation variability are investigated.

Systematic Errors in the Simulation of Mean and Variability of the Asian Summer Monsoon in Climate Models

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Systematic Errors in the Simulation of Mean and Variability of the Asian Summer Monsoon in Climate Models

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More than 125 years ago, H. Blanford envisioned that the tropical Indian Ocean not only supplies the moisture for the Asian summer monsoon rains but that it is also vitally 'linked to the intensity of the monsoon through coupled land-atmosphere-ocean phenomena. Despite sustained improvements in climate models, simulating the monsoon annual cycle and its variations at intraseasonal to interannual time scales remains one of the most difficult challenges for the modeling community. There are a number of reasons for the models' poor performance. First, and perhaps foremost, is the complexity of the monsoon, which involves the interaction of phenomena on a variety of time (intraseasonal to interannual and longer) and space (regional to global) scales. Secondly, key physical processes (e.g., the generation of clouds) are not adequately represented in the models. Thirdly, we lack the necessary observations that are needed to provide a more complete understanding of air-sea-land interaction processes that shape the mean monsoon and its variability.

In this study, the ability of the current state-of-the-art coupled models to simulate the summer season (June-September) climatology of key variables, such as precipitation, soil moisture, the vertical distribution of moisture, vertical velocity, sea surface temperature, and salinity will be presented. In particular, our diagnostics will focus on: (i) the sensitivity to the models' basic state in representing the spectrum of monsoon variability, including synoptic systems to the ENSO-monsoon association; and (ii) the role of air-sea interactions over the tropical Indian Ocean in ameliorating systematic errors in the simulation of the mean monsoon and its variability. In addition, results from sensitivity experiments with linear atmospheric models, and diagnostics from newly available satellite observations will be discussed.

Proposed Metrics to Evaluate Coupled Model Performance in the Tropical Pacific

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Proposed Metrics to Evaluate Coupled Model Performance in the Tropical Pacific

M. Balmaseda, on behalf of the Pacific Panel

(A. Timmerman, A. Clements, M. McPhaden,.....)

The Pacific Panel is compiling a list of indices that can be used as metrics to evaluate the performance of coupled models in the tropical Pacific. The emphasis is on the mean state, seasonal cycle and ENSO variability. Some of the indices have been widely used in the literature, and they need little introduction. Others, more innovative, will be explained and discussed in detail. The proposed indices will be calculated either from observations and/or from climate reanalysis, and, when possible, error bars will be given.

SLP Interannual Variability over Southern South America as Represented by IPCC-AR4 Models

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SLP Interannual Variability over Southern South America as Represented by IPCC-AR4 Models

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Global climate model outputs available for the preparation of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) were evaluated to assess the ability to represent the predominant patterns of SLP interannual variability over a region of the Southern Hemisphere that comprises Southern South America and part of the South Atlantic and South Pacific oceans. Models with good representation of the dominant regional patterns were selected to analyze future scenarios. Predominant patterns of SLP and their evolutions were analyzed under different SRES scenarios.

Monthly mean SLP fields of NCEP/NCAR reanalyses and of GCMs were analyzed over an area between 20°S-45°S and 130°W-0°. Two different periods were studied: one associated with present climate between 1978 and 2000, and the other associated with future climate, between 2001 and 2100. The relatively short period used to represent the present climate was selected because the reanalyses are more representative of real data over the oceanic areas only after 1978 when satellite data began to be fully used. The evaluation of the simulations of present climate was done using Climate of the 20th Century (20C3M) experiments; the scenarios A1B, A2 and B1 were used for the period 2001-2100.

The identification of the dominant SLP patterns over the selected region was performed through a T-mode Varimax Rotated Principal Components Analysis (PCA) using the NCEP/NCAR reanalyses and the outputs from some selected models using the correlation matrix as input. To evaluate the ability of the GCMs to represent the "observed" SLP fields, linear spatial correlation coefficients between monthly mean SLP fields derived from the NCEP/NCAR reanalyses and from GCMs were calculated. Likewise, for the same purpose, linear correlation coefficients between the PCs derived from the NCEP/NCAR reanalyses and from the GCMs outputs were also calculated.

The T-mode PCA of the monthly mean SLP obtained from NCEP/NCAR reanalyses shows that there are three predominant patterns that characterize SLP fields over the extensive region of the Southern Hemisphere analyzed. PC1 represents the summer surface circulation with the South Atlantic and South Pacific highs in their southernmost positions. PC2 and PC3 represent the winter circulation with the South Atlantic and South Pacific in the northernmost position (PC2) and a surface pattern that characterizes the frontal activity during that season (PC3). Time series of the three PCs show a positive linear trend of the summer mode and slightly negative trends for the winter indicating that the summer mode increased at the expense of the winter ones.

Monthly correlation coefficients between the output from the GCMs and the NCEP/NCAR reanalyses show that all of the models represent adequately the SLP fields during most of the year with the lower correlations during the austral autumn (March-April-May). The GCMs with better representation of the monthly mean SLP fields are UKMO_HadGEM1, UKMO_HadCM3, ECHAM5/MPI-OM, IPSL-CM4 and CNRM-CM3, with correlation coefficients higher than 0.75 for all months. Application of PCA to the GCMs outputs of four of these models show that most of them represent the same spatial and temporal variability identified with NCEP/NCAR reanalyses. These GCMs show the same three dominant patterns and also represent adequately the linear trends, showing an increase of the summer mode at expense of the winter ones, especially in UKMO_HadGEM1, ECHAM5/MPI-OM and CNRM-CM3. This result indicates that these set of GCMs are able to represent not only mean fields but also the interannual variability of SLP over the analyzed region.

The PCA performed to the GCMs output corresponding to the future period shows approximately the same predominant patterns of SLP obtained for the 20C3M experiments. The time series associated indicate that the increase of the summer mode at the expense of the winter one will continue. These trends are more pronounced in the A2 scenario showing that the changes are related to differences between atmospheric concentrations gases.

Diurnal Ocean-Atmosphere Coupling and Its Climate Impacts

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Diurnal Ocean-Atmosphere Coupling and Its Climate Impacts

Presenting author: D.J.Bernie

Other authors: S.J.Woolnough, E.Guilyardi, G.Madec, J.M.Slingo, J.Cole

The impact of diurnal ocean-atmosphere interaction has previously received little attention, though its role in numerous aspects of the tropical climate has previously been hypothesized and observed. This study examines the impact of the diurnal cycle of ocean-atmosphere coupling on the variability of the tropical climate.

Forced OGCM simulations are used to assess the impact of the diurnal cycle on the intraseasonal SST response to the Madden-Julian Oscillation (MJO) during TOGA-COARE. The diurnal cycle is shown to increase the magnitude of the SST response to the MJO by around 25%, implying a potential role for the diurnal cycle in the coupled nature of the MJO. It is also demonstrated that, in the Pacific, the diurnal cycle of turbulence in the upper ocean modifies the vertical exchange of momentum between the equatorially divergent Ekman layer and geostrophic convergence at depth. This results in 10% stronger Pacific sub-tropical cells and equatorial upwelling.

The variability of the coupled system is then examined in CGCM simulations. At seasonal time scales the dynamical and thermodynamical impacts of the diurnal cycle in the upper ocean are shown to increase the strength of Bjerknes feedbacks in the tropical Pacific, leading to an increase in the seasonality of the coupled system.

Lag correlations and composites are then used to examine the impact of the diurnal cycle of ocean-atmosphere coupling on the MJO. The inclusion of the diurnal cycle is shown to lead to a more coherent MJO due to the improved representation of ocean-atmosphere coupling.

The Land-Surface-Cloud Interaction

Primary Author: Betts, Alan

The Land-Surface-Cloud Interaction

Alan K. Betts

On timescales of a day and space scales of order 800km, the climate over land is a complex balance of many highly coupled processes. In the atmosphere, water vapor convergence is linked to precipitation and clouds, which in turn modify the radiation field. The surface energy budget is strongly influenced by the cloud field, and the availability of water for evaporation. Cloud feedbacks in models have long been regarded as a major source of uncertainty in climate modeling. We propose that the effective cloud albedo at the surface is a missing and observable link, which connects the cloud fields to both surface and large-scale processes. We have developed a methodology using daily averaged data for understanding the coupling between physical processes in models, so that different models can be compared with each other and with data. We illustrate this first using model data from ERA 40 for the Madeira River, a south-western basin of the Amazon, which has a large seasonal cycle with a dry season in the austral winter. Daily-mean land-surface fluxes and state variables can be used to map the transitions of the surface 'climate' of a model; and to quantify the links between the soil moisture, the mean cloud-base and cloud field, the short-wave and long-wave radiation fields at the surface, the vertical motion field, the atmospheric precipitable water and the surface precipitation. We then use long time-series of daily mean data from the three BERMS flux sites in central Saskatchewan to explore biases in ERA-40 on the grid-point scale, and to study the relationships between surface variables and fluxes and cloud cover in the observed and model data sets. On the seasonal timescale the biases in ERA-40 of temperature and humidity are small, but the model has a high bias of evaporative fraction in the warm season, and except in mid summer a low bias of reflective cloud, which peaks in mid winter. Reanalysis data for sub-basins of the Mississippi are then used to explore the links between these processes on river basin scales, using for evaluation observed surface precipitation and surface shortwave fluxes derived by the International Satellite Cloud Climatology Project. The satellite data show that ERA-40 has the same seasonal bias in cloud albedo [reaching -10% in winter) over the Mississippi as was seen in central Saskatchewan from comparisons with the BERMS flux-tower measurements. Other critical model relationships are explored. Moisture convergence leads to clouds and precipitation, but the relation of the diabatic precipitation heating and the surface cloud radiative forcing, while a function of cloud albedo, is largely independent of moisture convergence, although it does depend on cloud base. The surface cloud radiative forcing determines the surface net radiation, while evaporative fraction is primarily determined in the model by temperature and soil water. Near-surface relative humidity, the lifting condensation level, soil moisture and precipitation are also closely linked.

Developing a Performance Metric for the Simulation of Rainfall Variability and Change: The Case of the Sahel

Primary Author: Biasutti, Michela

Developing a Performance Metric for the Simulation of Rainfall Variability and Change: The Case of the Sahel

Michela Biasutti (LDEO)

Can a good performance in the simulation of the 20th century lend credence to the prediction for the 21st century? We explore this question in the context of changes in Sahel rainfall. We present a statistical analysis of the pre-industrial, 20th century and A1B simulations of 19 models that shows how, while the IPCC AR4 models show excellent agreement in simulating the response of Sahel rainfall to the 20th century forcings, they grossly disagree in their outlook for the 21st century. Moreover, we show that the degree of similarity in simulations of the annual cycle and of mechanisms of interannual variability of Sahel rainfall in the 20th century constitute a poor predictor for the similarity of predictions in the 21st century. Finally, we offer a template for testing the validity of a performance metric.

The Aqua-Planet Experiment: Comparison of Atmospheric GCM Simulations on a Water-Covered Earth

Primary Author: Blackburn, Michael

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The Aqua-Planet Experiment (APE) is one of several benchmark experiments used to test and evaluate global atmospheric circulation models used in weather forecasting and climate research. In APE the models simulate the climate of idealised water-covered versions of Earth, with the reduced complexity being designed to aid understanding of model behaviour.

Experiments with zonally symmetric sea surface temperatures (SSTs) investigate each model's range of tropical circulation, from a single equatorial convergence zone to a tropic-wide radiative-convective equilibrium. Experiments adding local- or larger-scale SST anomalies in the tropics investigate the local enhancement of precipitation and its far-field effects.

Initial results reveal a large inter-model range in many aspects of the circulation and its response to changes in SST, despite the idealised setting. In the tropics the models differ in the mean amplitude of the hydrological cycle, and there is a wide variety of (spatial and temporal) variability in tropical precipitation. These differences contribute to a large 30Wm^{-2} inter-model range in planetary energy balance.

Additional diagnostics are being sought to investigate the models' tropical variability. Highly constrained experiments to remove (e.g. radiative) feedbacks are planned, in order to reduce specific inter-model differences and identify their sources.

Uncertainties in Cloud Feedbacks and Their Implication for Climate Sensitivity

Primary Author: Bony, Sandrine

Uncertainties in Cloud Feedbacks and Their Implication for Climate Sensitivity

Climate sensitivity, commonly defined as the global mean surface temperature change caused by a doubling of atmospheric carbon dioxide, plays a central role in climate change studies. The range of climate sensitivity estimates from general circulation models remains large. This range stems primarily from intermodel differences in the treatment of climate feedbacks, and particularly cloud feedbacks.

After identifying some of the reasons for the differences in cloud feedbacks produced by the current generation of climate models (AR4 GCMs), we will highlight those which seem to be associated with systematic errors in models. Finally, we will discuss how observations might be used in a near future to constrain some crucial components of cloud feedbacks in large-scale models.

A Distance-based Methodology for Comparing Longer-Term, Multi-Metric Model Performance

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A Distance-based Methodology for Comparing Longer-Term, Multi-Metric Model Performance

In an ongoing regional risk assessment, climate projection distribution functions are being developed for Northern California, representing an ensemble of IPCC AR4 projections produced by 17 coupled models simulating either SRES A2 or B1. It is questioned whether these distribution functions should be built to reflect unequal model-weighting derived from relative model performance in the 20th Century Climate Experiment (20C3M).

To explore this question, 59 20C3M simulations from the same 17 models were evaluated statistically during 1950–1999. These statistics were then compared to reference conditions during the same period (NCEP/NCAR Reanalysis, Kaplan Extended SST v2). This comparison was made for a range of statistical metrics applied to different global variables, local variables, and teleconnections relevant to Northern California climate (i.e. local precipitation and surface air-temperature, North Pacific sea level pressure index, and Nino3 sea surface temperature index). Metric-specific differences were then aggregated using a distance scheme to reveal multi-metric model-to-reference similarity. Relative model weights were derived from similarity calculations and ultimately used in producing weighted estimates of climate projection distribution functions.

Presentation will provide an overview of methods, but focus mainly on results from 20c3m similarity analyses. Results show that although bias for a given metric can vary significantly among the models analyzed, the relative degrees of bias varies considerably depending on the variable and/or metric. Moreover, consideration of multiple metrics was found to significantly dampen the range of relative model weights.

Combining Top-Down and Bottom-Up Approaches to Improve Boundary Layer Parametrization for NWP and Climate

Primary Author: Brown, Andrew

Additional Authors: Bob Beare, Anton Beljaars, Hans Hersbach and Adrian Lock

Combining Top-Down and Bottom-Up Approaches to Improve Boundary Layer Parametrization for NWP and Climate

Andrew Brown (1), Bob Beare (1), Anton Beljaars (2), Hans Hersbach (2) and Adrian Lock (1)

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Two different but complementary methods have been used to identify and reduce biases in the Met Office Unified Model due to the turbulence parametrization. Both the 'top-down' approach of a detailed analysis of short-range NWP errors and the 'bottom-up' approach provided by detailed process studies led to the conclusion that excessive mixing in stable conditions and insufficient mixing in unstable conditions significantly contributed to model bias. Accordingly a modified scheme (featuring reduced mixing in stable conditions over the sea and the inclusion of non-local momentum mixing in convective conditions) has been introduced to both the NWP and climate versions of the Met Office Unified Model.

The top-down approach required short-range NWP errors to be conditionally sampled in a physically relevant way. Over land, it was found that both the Met Office and ECMWF models show systematic biases, with near surface winds which are too weak by day (especially in summer), and too strong by night. Over sea, wind direction was used as a proxy for stability, and strikingly different biases in wind speed and direction (relative to QuikSCAT and conventional observations) were found in northerly and southerly wind conditions.

In the bottom-up approach, single column model simulations were compared with idealized large-eddy simulations and observations. These tests highlighted failings in the traditional parametrizations, and the modified versions were developed.

Energy Dissipation in the Tropical Ocean and ENSO Dynamics

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Energy Dissipation in the Tropical Ocean and ENSO Dynamics

Jaclyn N. Brown and Alexey V. Fedorov

State-of-the art coupled models exhibit a wide range of behavior in the tropical Pacific, particularly when simulating ENSO. Here, we propose an energetics metric to compare and contrast a variety of ocean-only and coupled models. Previous studies have shown that winds act on the ocean by affecting the buoyancy forcing, modifying the slope of the isopycnals and changing the Available Potential Energy (APE) of the system, so that

$$d(APE) = \text{Wind_Work} - \text{Dissipation}$$

$\frac{d(APE)}{dt}$

The present study focuses on the role of energy dissipation in this balance due to various factors including turbulent mixing and coastal Kelvin waves leaving the basin. Firstly we test the robustness of this equation by using a variety of ocean-only models and data-assimilation products, in order to establish a baseline for this relationship. We show that for interannual variability the models are similar however seasonally they behave quite differently, some having a pronounced semi-annual signal. With the baseline established, we apply our method to the IPCC coupled model simulations. We find that the net dissipation rates and the mechanisms for dissipation vary greatly from one model to the next, for a number of different physical reasons. One of the striking differences between coupled models is in the way they partition energy between the seasonal cycle and interannual variability, which is investigated within the same framework. Further, we explore the differences in the ocean energetics that occur due to the emergence of a double ITCZ in some models, and also investigate the relationship between the effective coupling strength of a given model and its dissipative characteristics. Ultimately, we propose this energy-based analysis as an effective diagnostic tool for assessing and improving model performance.

Composite Representation and Scenarios of Surface Temperature and Precipitation in Southern South America by IPCC-AR4 Models

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Composite Representation and Scenarios of Surface Temperature and Precipitation in Southern South America by IPCC-AR4 Models

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The objective of the present work is to evaluate the ability of a set of global climate models available for the preparation of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) to represent monthly and annual surface temperature and precipitation fields over Southern South America. Monthly fields derived from different models were compared with the University of Delaware database available in a $0.5^\circ \times 0.5^\circ$ grid for the period 1950-99. Those models with good representation of the dominant regional patterns in the area delimited by 15°S - 60°S and 80°W - 45°W were selected to analyze future seasonal and annual temperature and precipitation scenarios. The evaluation of present climate model simulations was done using Climate of the 20th Century (20C3M) experiments and scenarios A1B and A2 were used to prepare climate change scenarios for the period 2020-2029.

GCMs skill to represent the observed temperature and precipitation fields was assessed from the linear spatial correlation coefficients between monthly mean fields derived from the observed database and from GCMs. Differences between observed and GCM annual mean fields were also calculated to identify regions with large biases.

Surface temperature linear monthly correlation coefficients are higher than 0.7 for all the analyzed GCMs with the lowest values during the summer months. Spatial representation of the annual mean temperature show that all GCMs overestimate its magnitude in about 5°C in the central region of the Andes and underestimate it in 3°C in the Patagonia. In the Plata Basin differences among GCMs are evident with some of them (i.e. MPI_ECHAM5, GFDL_CM2_1, CNRM_CM3_1 y CSIRO_Mk3_0) overestimating the annual mean temperature.

Precipitation analysis shows that the lowest linear spatial correlation coefficients are observed during the austral autumn and spring months. All GCMs show some similar patterns: underestimation of annual rainfall over the Plata Basin and central Chile and overestimation over the central-western of Argentina, northern Chile, Bolivia and to the south of 40°S .

Seasonal and annual surface temperature and precipitation scenarios for 2020-2029 based on 1961-90 were prepared composing those GCMs with better agreement with the present climate. The statistical significance at a 5% level was calculated showing a significant regional warming in the annual mean temperature between 0.7°C and 1.4°C . Annual precipitation scenarios show areas like the Humid Pampas and the southern region of La Plata basin with increasing rainfall between 1% and 8% and significant decreasing values in all the mountain region of Los Andes and Patagonia. Only a region of the Humid Pampas, its size depending on the SRES scenario, shows a significant positive rainfall change.

Tropical Pacific Interannual Variability in Coupled Climate Models: The Role of Mean Ocean Conditions vs. Atmospheric Forcing

Primary Author: Capotondi, Antonietta

Analyses of the 20th Century integrations performed with the latest generation of climate models for the IPCC Fourth Assessment Report (AR4) show a considerable improvement in the simulation of interannual variability in the tropical Pacific. However, in most models ENSO events still tend to occur too frequently and regularly than in nature. Several studies have emphasized the importance of the spatial pattern of the anomalous zonal wind stress to determine the ENSO timescale. In particular, the meridional scale of the wind stress anomalies influences the latitude range over which extratropical Rossby waves are generated. Due to the decrease of Rossby wave phase speed with increasing latitude, this can affect the adjustment time of the equatorial thermocline.

Interannual variability is also associated with mass recharge/discharge to/from the equatorial thermocline, as described by the "recharge oscillator" paradigm for ENSO. Due to the presence of an erroneously extensive South Pacific Convergence Zone (SPCZ) in the Southern Hemisphere, a bias exhibited to different degrees by most climate models, the mean flow pathways toward the equator can be severely altered, and may limit the southward extension of the recharge/discharge process. Here we use one of the climate models developed at the National Center for Atmospheric Research, CCSM3, a model with a regular biennial ENSO, and a pronounced SPCZ bias, to examine the relative roles of the mean oceanic pathways and anomalous wind forcing in determining the ENSO's spectral characteristics.

A Comparison of the Stratus Clouds in the NCEP CFS03 and NCAR CCSM3

Primary Author: Chang, Ching-Yee

A Comparison of the Stratus Clouds in the NCEP CFS03 and NCAR CCSM3

Ching-Yee Chang

UMD

The stratus clouds over the Southeast oceans can reduce the incoming solar radiation and cool the sea water. Many studies relate the notable models systematic warm biases over the southeastern basins to the deficiency of the simulated stratus clouds. In this study, the model stratus clouds of the NCEP CFS03 and NCAR CCSM3 are compared against those of the ERA40 reanalysis and of the ISCCP. This study indicates that the deficiency of the stratus clouds may be related to the failure in simulating the subtropical temperature inversion. The temperature inversion can cap the boundary layer and help the formation of stratus clouds. The lack of the temperature inversion may result in less cloud condensates and thus reduce the stratus clouds.

The Origin of Systematic Errors in the GCM Simulation of ITCZ Precipitation over Oceans

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The Origin of Systematic Errors in the GCM Simulation
of ITCZ Precipitation over Oceans

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This study provides explanations for some of the experimental findings of Chao (2000) and Chao and Chen(2001) concerning the mechanisms responsible for the ITCZ in an aqua-planet model. These explanations are then applied to explain the origin of some of the systematic errors in the GCM simulation of ITCZ precipitation over oceans, including the origin of the "false double ITCZ." The ITCZ systematic errors are highly sensitive to model physics and by extension model horizontal resolution. The findings in this study along with those of Chao (2000) and Chao and Chen (2001, 2004) contribute to building a theoretical foundation for ITCZ study. A few possible methods of alleviating the systematic errors in the GCM simulation of ITCZ are discussed. This study uses a recent version of the Goddard Modeling and Assimilation Office's Goddard Earth Observing System (GEOS-5) GCM.

Errors in Polar Clouds and Radiative Forcing in the Reanalysis Models

Primary Author: Chapman, William

To assess the performance of numerical models in simulating polar clouds, surface radiative fluxes, and corresponding cloud-radiative interactions, we compare the observed (ARM, Barrow) cloud fractions, downwelling shortwave and longwave fluxes and the cloud radiative forcing against those obtained by four recent reanalysis projects (NCEP/NCAR, ERA40, JRA-25, and NARR) for Arctic locations. For a summer month (June 2001), the ERA40 reasonably simulates cloud fraction timeseries correlating at 0.87 with the corresponding observed ARM data. Simulated cloud fractions for the NCEP/NCAR reanalysis, however, correlate at only 0.29 missing an extended period of low, thin clouds early in the month. The JRA-25 cloud fractions correlate with observations at 0.60. Values of downwelling shortwave flux for all the reanalyses are generally much too high with errors up to 300 Wm^{-2} during cloudy periods at the daily solar maxima, indicating that the models are not correctly capturing the radiative and/or spatial characteristics of the observed cloud cover. Downwelling longwave radiative fluxes appear to be more correctly simulated than the shortwave flux when the models correctly simulate cloud fractions (i.e., ERA40 “ frequently, NCEP/NCAR “ infrequently). Periods with discrepancies between observed and simulated cloud fractions can have large errors ($\sim 75 \text{ Wm}^{-2}$) in the downwelling radiation flux. The net effect of clouds on the radiative balance at the polar surface is seen by evaluating the cloud radiative forcing produced by each reanalysis model as a function of season and cloud fraction for each reanalysis’s period of record. The cloud radiative forcing simulated by all the models agree in a seasonal sense with the signs of the observed forcing: positive during winter, spring and autumn and negative in the summer. The magnitudes of the cloud radiative forcing decrease linearly as a function of cloud fraction for observations and the NCEP/NCAR reanalysis, but decrease much more rapidly in the ERA40 and JRA-25 than observations with decreasing cloud fraction. While these models appear to be more successful in correctly replicating the observed cloud fraction than the NCEP/NCAR model, the simulated clouds in these models may be too optically thin and the models too insensitive to radiative effects of cloud covers less than 80-90%.

The NCAR CCM as a Numerical Weather Prediction Model

Primary Author: Cocke, Steve

The NCAR CCM as a Numerical Weather Prediction Model

Steven Cocke
FSU

The NCAR CCM is one of the most extensively studied climate models in the scientific community. However, most studies focus primarily on the long term mean behavior, typically monthly or longer time scales. In this study we examine the daily weather in the GCM by performing a series of daily or weekly 10 day forecasts at moderate(T63) and high (T126) resolution. The model is initialized with operational "AVN" and ECMWF analyses, and model performance is compared to that of major operational centers, using conventional skill scores used by the major centers. Such a detailed look at the CCM at shorter time scales may lead to improvements in physical parameterizations, which may in turn lead to improved climate simulations.

One finding from this study is that the CCM has a significant drying tendency in the lower troposphere compared to the operational analyses. Another is that the large scale predictability of the GCM is competitive with most of the operational models, particularly in the southern hemisphere.

A Comparison of Systematic Uncertainties in Perturbed Physics and IPCC AR4 Multi-Model Ensembles

Primary Author: Collins, Mat

Additional Authors: Ben Booth, Glen Harris, James Murphy, David Sexton and Mark Webb

A Comparison of Systematic Uncertainties in "Perturbed Physics" and IPCC AR4 Multi-Model Ensembles

Mat Collins, Ben Booth, Glen Harris, James Murphy, David Sexton and Mark Webb

Hadley Centre for Climate Change, Met Office, UK.

While the AR4 archive provides a large gene-pool of possible models of long-term climate change, the perturbed physics approach (in which perturbations are made to key uncertain parameters in a single modelling framework allows us to build a more controllable system for quantifying uncertainties and expressing climate change in terms of the probability of different outcomes (see Sexton et al. abstract). Yet there is a potential for the perturbed physics approach to be "structurally constrained" thus limiting the range of responses that may be explored.

Here we compare and contrast sources of uncertainty in perturbed physics and multi-model ensembles. Focus will be on:

1. Global mean change, in which perturbations are made to parameters in the atmosphere component, the ocean component and the sulphur-cycle component in turn. By isolating the effects of uncertainty in feedbacks associated with each component, it is possible to contrast the relative impacts of uncertainties in different feedbacks. Comparison with the AR4 archive will be performed to reveal the overlap in global mean response.
2. Large-scale regional patterns, which will be compared between the different ensembles to assess the extent to which (i) the perturbed physics approach can mimic the behaviour of the AR4 ensemble and (ii) the sign and magnitude of the response can be linked to systematic uncertainties in the simulation of present-day climate and climate change.

In addition, plans for future work to produce a perturbed physics ensemble with HadCM3 coupled to a carbon cycle model will be outlined together with a plan to produce an ensemble in which parameters are perturbed in all components simultaneously. Comparisons with similar perturbed physics ensembles run to predict seasonal to decadal variations in climate will be explored by Murphy et al. in their abstract.

Radiative Transfer in Global Models: Problems and Prospects

Primary Author: Collins, Bill

Radiative Transfer in Global Models: Problems and Prospects

The global radiative budget is one of the most important aspects of the coupled climate system. Radiative imbalances introduced by changes in atmospheric composition and land surface properties comprise the most important drivers for recent climate change. Fortunately, radiative transfer is one of the few processes in global climate models (GCMs) that can be evaluated rigorously using benchmark models, theory, and observational "closure" studies.

In this presentation, we evaluate the fidelity of radiative transfer across the multi-model ensemble assembled for the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). Several lines of evidence indicate a much greater diversity in the disposition of solar and terrestrial radiation among these models than can be readily explained by differences in, e.g., aerosols, short-lived greenhouse gases, etc. These lines of evidence include the range of estimates of atmospheric absorption from the IPCC ensemble and offline comparisons of the GCM radiative parameterizations against benchmark calculations. The range in radiative budgets among the GCMs affects efforts to evaluate the simulated historical record. It also affects efforts to attribute the inter model differences in response to anthropogenic emissions to differences in, for example, cloud processes. The presentation concludes with several promising theoretical and empirical approaches to improve the fidelity of radiative transfer in climate models.

Simulation of the West African Monsoon System

Primary Author: Cook, Kerry

Simulation of the West African Monsoon System

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The West African monsoon system exhibits unusual structure in both space and time that makes it a particular challenge for climate models. But this is one of the most important systems to properly simulate, since much of the population of northern Africa is vulnerable to climate variations and change through a strong dependence on local agriculture. This paper will provide an overview of the West African monsoon system, with the goal of identifying structures and processes within the system that a model needs to capture with some fidelity for a credible simulation of change and variability in this region. These include three important climatological jet features -the African easterly jet, the tropical easterly jet, and a low-level westerly jet that brings moisture onto the continent from the Atlantic - the southerly monsoon flow across the Guinean coast, and the thermal low/Saharan high complex. Important time-dependent features include the monsoon jump and monsoon breaks.

A comparison across a number of models, including atmosphere-only regional models and GCMs, coupled ocean/atmosphere regional models and GCMs (the AR4 models), and a regional ocean/atmosphere/vegetation model, will be used to understand to what extent we are able to produce a credible simulation of the West African monsoon system with current modeling tools, and what effort may produce improvements. Systematic errors will be reported and evaluated for both coupled and uncoupled models for the climatology of the summer precipitation and large scale circulation, and for the physics of the monsoon onset.

Use of Time Series Reference Sites to Assess Numerical Weather Prediction Reanalyses: Surface Heat Fluxes and Surface Cloud Forcing in the Eastern Tropical Pacific

Primary Author: Cronin, Meghan

Use of Time Series Reference Sites to Assess Numerical Weather Prediction Reanalyses: Surface Heat Fluxes and Surface Cloud Forcing in the Eastern Tropical Pacific

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Data from the Eastern Pacific Investigation of Climate Studies (EPIC) mooring array are used to evaluate the annual cycle of surface cloud forcing and surface air-sea heat fluxes in the far eastern Pacific stratus cloud deck/cold tongue/intertropical convergence zone complex. Surface cloud forcing is defined as the observed downwelling radiation at the surface minus the clear-sky value. The relative amount of solar radiation reduction and longwave increase depends upon cloud type and varies with latitude. A statistical relationship between solar and longwave surface cloud forcing is developed for rainy and dry periods and for the mean annual cycle in six latitudinal regions: northeast tropical warm pool, ITCZ, frontal zone, cold tongue, southern, and stratus deck regions. While International Satellite Cloud Climatology Project (ISCCP) radiative flux data (FD) compares well with the buoy cloud forcing observations and empirical relations, the NCEP Reanalysis 2 (NCEP2) and 40-year ECMWF Re-Analysis (ERA-40) show large discrepancies. In particular, NCEP cloud forcing at the equator was nearly identical to the ITCZ region and thus had significantly larger solar cloud forcing and smaller longwave cloud forcing than observed. The net result of the solar and longwave cloud forcing deviations is that there is too little radiative warming in the ITCZ and southward to 8°S during the warm season and too much radiative warming under the stratus deck at 20°S and northward to the equator during the cold season. All reanalyses (including to a certain extent NCEP Reanalysis 1) appear to have a latent heat loss that is too large in the convective regions. NCEP1 has too weak latent heat loss throughout the stratocumulus region at and south of the equator during the cool season. The net effect is that NCEP2 and to a lesser extent ERA40, has large negative net surface heat flux (that is surface heat loss) biases relative to the buoy values. NCEP1 net surface heat flux errors are dominated by the radiative biases and result in anomalous net surface heat loss in the ITCZ and during the warm season at and south of the equator, and anomalous net surface heat gain at and south of the equator during the cold season when the stratus deck tends to form.

The ten EPIC TAO moorings along 95°W and the IMET mooring at 20°S 85°W are part of the network of global time series reference sites. Similar types of analyses and assessments are planned for other time series reference sites including the Kuroshio Extension Observatory (KEO) and the Ocean Weather Station PAPA. A surface buoy will be deployed at OWS PAPA in June 2007.

Intrinsic Errors in Physical Ocean Climate Models

Primary Author: Hecht, Matthew

Intrinsic Errors in Physical Ocean Climate Models

The essential requirement for ocean climate models, in coupled applications, is simply that they produce realistic sea surface temperatures, for historical climate and future scenarios. Working to more faithfully satisfy this simple requirement, of course, one finds an entire community of ocean modelers to complement the community of atmospheric modelers better represented at this meeting.

I will briefly survey some of the ocean modeling issues of broader relevance to climate scientists, touching on errors of a numerical nature, and on errors associated with the set of processes we choose to resolve or parameterize.

Tropical Eastern Pacific Climate, Biases, and Sensitivities

Primary Author: de Szoeke, Simon

Tropical Eastern Pacific Climate, Biases, and Sensitivities

Simon de Szoeke

International Pacific Research Center

Many coupled models have difficulty faithfully reproducing the seasonal cycle and meridional distribution of precipitation in the tropical eastern Pacific. Coupled general circulation model simulations of the 20th century climate for the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) are compared amongst each other and with the IPRC Regional Ocean-Atmosphere Model (IROAM). Simple metrics of the seasonal-meridional distribution of sea surface temperature (SST) and precipitation are introduced. IROAM and a few AR4 simulations reproduce the observed northward-displaced intertropical convergence zone (ITCZ) and seasonal cycle. Experiments with IROAM show that shallow cumulus and drizzle parameterizations have an effect on the meridional distribution of SST, precipitation, and equatorial wind.

The Sensitivity of HadGAM1 Dynamics to the Vertical Structure of Tropical Heating

Primary Author: Dearden, Chris

The Sensitivity of HadGAM1 Dynamics to the Vertical Structure of Tropical Heating

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Investigation of the atmospheric response to localised tropical diabatic heating using a linear, steady-state model (such as A. E. Gill's 'shallow water' approach) has proven to be a useful technique for elucidating the essential features of the large-scale tropical circulation. More recently, this method has been expanded and applied to more sophisticated primitive equation models (e.g. Wu et al. 2000, Amer. Meteor. Soc.), showing that the response of the atmosphere depends highly on the vertical distribution of diabatic heating.

Given that low-level tropical circulation errors exist in the current Hadley Centre AGCM (HadGAM1), it is of relevance to establish the sensitivity of the model dynamics to the tropical heating profile, and also to diagnose how well the model parametrization schemes represent the vertical structure of the heating. To achieve these aims, the technique of studying heat-induced tropical circulations is applied to the dry dynamical core of HadGAM1. This idealised model atmosphere is initialised with a motionless basic state in hydrostatic balance, with no horizontal temperature gradients. A circulation is then driven exclusively by a localised tropical heat source which is centred along the equator at some arbitrary longitude. Results are shown which suggest that HadGAM1 dynamics respond to changes in the vertical structure of heating in a way that is consistent with theory; however, analysis of the diabatic heating profile taken from a HadGAM1 aqua-planet simulation show that the model physics produces a more bottom-heavy heating profile than is expected. The excessive low level heating may be due to a lack of representation of older, decaying convective activity which typically produces stratiform precipitation. This missing physical process also has wider implications for coupled atmosphere-ocean configurations, where the excessive heating produces overly-strong easterly wind stresses which contribute to cold SST biases along the equatorial Pacific and the poor simulation of ENSO.

The Role of Land Surface Processes in the Indian Summer Monsoon: A High-Resolution GCM Study

Primary Author: Demory, Marie-Estelle

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The Role of Land Surface Processes in the Indian Summer Monsoon: A High-Resolution GCM Study

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The Indian summer monsoon is a vital climate process, affecting the lives of many millions of people. A better understanding of the underlying mechanisms is important for prediction.

In this study, we investigate the impact of land surface processes on the Indian monsoon. In fact, previous studies (e.g. Becker et al. 2001) have investigated the importance of snow cover in Eurasia for the onset of the monsoon, which may be linked by a modification of the positioning of the subtropical jet and thus circulation. Moreover, other studies (e.g. Ferranti et al. 1999) indicated the existence of a positive feedback between soil moisture and precipitation, which may have an impact on the maintenance of the summer Indian monsoon.

For the purpose of investigating these two mechanisms, we use the high-resolution (60km) atmospheric version of the Hadley Centre's general circulation model HadGEM1 (NUGAM, developed as part of the UK-Japan Climate Collaboration). We show that lower resolution versions of HadGEM1 have poor skill at representing the monsoon; NUGAM performs better, probably due to the fact that mesoscale mountains are resolved, affecting both Himalaya snow cover and local circulation. However the soil remains too dry in India during the summer and precipitation too little. As further sensitivity tests for this study, soil physical parameters as well as the treatment of snow-melt infiltration have been modified.

Results from the first experiment indeed show an improvement in the development of the Indian monsoon, which still needs further investigation. The land surface climate of other regions of the world is also better represented, with the reduction of a significant warm bias over land, present in HadGEM1 at all resolutions.

Tendency Errors in a Climate Model: Iterative Estimation

Primary Author: Deque, Michel

Tendency Errors in a Climate Model: Iterative Estimation

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In climate modeling, contrary to short-range forecasting, systematic errors are measured as the difference between the equilibrium reached (after a couple of months of integration in the case of the atmosphere, after a few decades for an ocean model although a slow drift can maintain for centuries) and a long term average of observations or reanalyses. In this approach, the systematic error is a residual of possibly compensating physical errors (e.g. cooling by too much low clouds and warming by erroneous advection). Moreover, the models are calibrated in order to minimize this kind of systematic error. Validating a model this way can be compared to validating a statistical prediction on the learning sample. At the end of the 1990's, the POTENTIALS European project proposed to analyze another type of modeling error, the tendency error. This error is measured by the initial departure between the model and an observed condition. This is closer to the approach in NWP. There can still be error compensation between the physical parameterizations (1D models as in the EUROCS European project are in this case the most appropriate approach), but the dynamics (i.e. the advection) is by construction error-free. The difficulty of the approach is that the numerical model does not start from an equilibrium state and one should avoid confusing tendency errors due to the physics and strong adjustments due to the numerics. The POTENTIALS approach proposed to nudge the velocity field with a tight constraint and the mass field with a looser constraint. With a strong relaxation, the model still generates numerical noise which pollutes the signal to be analyzed. With a weak relaxation, the model state may be far from the observed trajectory, and the tendency error includes additional errors or compensations.

The approach proposed here consists of considering an iterative approach in which the model is progressively corrected from its tendency error. The iterative process converges after a few iterations and seven 44-year (the ERA40 period) model runs are necessary to get a stable estimate with the ARPEGE AGCM. Although numerically expensive, this technique offers a new way of analyzing climate models. The cost of the method prevents from any ad hoc adjustment in the model, and a proof of its efficiency is obtained by the better behavior (mean climatology bias and seasonal forecast skill) of a model in which this error is subtracted directly from the equations. Results with ARPEGE in TL63-L31 will be shown.

Physical Features and Climatology of the Forecast Minus Analysis PV Field

Primary Author: Didone, Marco

Additional Authors: Huw C. Davies

Physical Features and Climatology of the "Forecast Minus Analysis" PV Field

Marco Didone and Huw C. Davies, IACETH Zurich, 2006

An alternative approach is set out for a systematic study of the difference between the forecast and contemporaneous analysis field of a particular predictions system (the ECMWF). The underlying rationale is two-fold. First this perspective's intrinsic properties imply that :- (a) nonconservation of error PV signifies either isentropic advection of the error across an ambient flow's PV gradient, the misrepresentation of diabatic or frictional processes, and /or error in the analysis field at the verification time; and (b) inversion of a particular feature of the error PV-field can (via attribution) account for error of the primary flow variables in both the in-situ and far-field. Second the dynamics of rapid error growth has been linked to distinctive PV-features of the error field.

Illustrations and interpretations are proffered of this difference when viewed in terms of PV for single autumn, winter and spring (2001/02) climatology. The evolution of this pseudo-error is investigated in term of forecast length with the pseudo-errors of forecasts of different lengths. Two model versions (T511 and T711) are compared. The results point out various discrepancies e.g. in the location of the jet between analysis and forecast which increases in amplitude for longer forecast length. Intercomparison of T511 and T711 results a convergence in error structure.

The Impact of a Dynamic CAPE Timescale on the Surface Energy Budget in the Hadley Centre GCM

Primary Author: Donners, John

Additional Authors: Pier Luigi Vidale

The parameterization of cumulus precipitation in a climate model impacts both the distribution and variability of precipitation and the model's climate sensitivity. In the UK Met Office Unified Model (UM), the strength of atmospheric convection depends on the convective available potential energy (CAPE), as controlled by a "CAPE timescale". In a companion paper (The impact of a dynamic CAPE timescale on precipitation variability and distribution in the Hadley Centre GCM) we show how an alternative treatment of convection is able to improve the timing and global distribution of convection.

By virtually eliminating time-step level oscillations in convection and the intermittent cloud-cover thereof, we have also been able to reduce the excessive amount of solar radiation impinging on the surface. This reduction is especially important over the oceans, where the optically thicker (in time) convective cloud deck decreases the error in solar radiation that reaches the surface by about 20 W/m². The weaker convection also keeps the marine boundary layer more moist, decreasing the excessively large latent heat flux, which has been shown to be responsible for too cold SSTs in the AOGCM. Over land, the reduction in excess short-wave has also a positive effect on the positive surface temperature bias, largest during the growing season, due to direct and indirect (via vegetation physiology) processes.

In summary, allowing the CAPE timescale to be longer than 1 hour in the UM has decreased the strength of the hydrological cycle and brought the surface heat balance closer to observations.

Analysis of Future Climate Change Projections for the Italian Alpine Region from the IPCC AR4 Simulations

Primary Author: Faggian, Paola

Additional Authors: Filippo Giorgi

Analysis of Future Climate Change Projections for the Italian Alpine Region from the IPCC AR4 Simulations

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The goal of this study is to survey the most recent projections of climate change for the Italian Region (with particular attention to the Alpine portion of the region) provided by the latest state of art AOGCMs in the PCMDI-IPCC archive.

We analyzed historical and future simulations of monthly-mean surface air temperature (T) and total precipitation (P) from an ensemble of 20 AOGCMs under three emission scenarios (A2, A1B and B1). In addition, we examined the evolution of sea surface temperature and sea level pressure to gain further insight into the projections.

We first compared simulated monthly-mean T and P from the IPCC models with Northern Italy observations for the period 1951-2000. We calculated bias indices for each model's performance at the annual timescale over the area covered by the observational dataset. A separate set of bias indices were calculated by also considering orographic information to distinguish mountain grid points from flat ones.

Using these bias indices, and different ensemble averaging methods, we then examined future climate change projections for this region under the three different emissions scenarios. Our analysis shows that the emissions pathway chosen has a greater impact on future simulated climate than the criteria used to obtain the ensemble means. Annual-mean T is projected to increase by about 2-4°C over the period 1990-2100 in the Alpine region, with roughly 5 °C in summer. Annual-mean P is projected to decrease during the 21st century, though with a likely wintertime increase. In spite of this light increase in winter, however, snowfall is expected to decline consistently over the century because of the warming.

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Systematic Errors for the International SGMIP (Stretched-Grid Model Intercomparison Project) Multi-Model Ensemble Simulations

Primary Author: Fox-Rabinovitz, Michael

Additional Authors: Jean Cote Bernard Dugas, Michel Deque and John L. McGregor

Systematic Errors for the International SGMIP (Stretched-Grid Model Intercomparison Project) Multi-Model Ensemble Simulations

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Jean Cote and Bernard Dugas, Environment Canada, Canada,

Michel Deque, Meteo-France, France, and

John L. McGregor, CSIRO, Australia

Variable-resolution GCMs using a global stretched grid (SG) with enhanced resolution over the region(s) of interest have proven to be an established approach to regional climate modeling providing an efficient regional down-scaling to mesoscales. This approach has been used since the early-mid 90s by the French, U.S., Canadian, Australian and other climate modeling groups along with, or as an alternative to, the current widely-used nested-grid approach. Stretched-grid GCMs are used for continuous/autonomous climate simulations as usual GCMs, with the only difference that variable-resolution grids are used instead of more traditional uniform grids. The important advantages of variable-resolution SG-GCMs are that they do not require any lateral boundary conditions/forcing and are free of the associated undesirable computational problems. As a result, SG-GCMs provide self-consistent interactions between global and regional scales of motion and their associated phenomena, while a high quality of global circulation is preserved, as in uniform grid GCMs. Climate simulation results obtained with the SG-GCMs have shown the maturity of the SG approach.

The international SGMIP-1 (Stretched-Grid Model Intercomparison Project, phase-1), using variable-resolution SG-GCMs developed at major centers/groups in Australia, Canada, France, and the U.S., has been conducted in 2002-2005. The next phase-2 of the project, SGMIP-2, has been conducted in 2005-2007. The results of the 12-year (1987-1998) climate simulations of SGMIP-1 and the 25-year (1979-2003) climate simulations of SGMIP-2 for a major part of North America as well as for the entire global domain, are available at the SGMIP web site: <http://essic.umd.edu/~foxrab/sgmip.html>, and are described by the authors in Fox-Rabinovitz et al. (2006). The SGMIP-2 high resolution multi-model ensemble simulations provided the possibility for a comprehensive analysis of systematic errors for regional and global products obtained with enhanced variable and uniform resolution.

The multi-model SGMIP regional climate simulations were conducted with enhanced 0.45 degree - 0.5 degree regional resolution for SG-GCMs, with the same or a similar number of global grid points as in a 1 degree x 1 degree global grid. The multi-model ensemble SGMIP global simulations are conducted with: (a) intermediate 1 degree x 1 degree resolution (with the same or a similar number of global grid points as in SGs), and (b) fine 0.5 degree x 0.5 degree resolution. The SGMIP SG-GCM simulations are analyzed in terms of studying the impact of high regional resolution on efficient downscaling to realistic mesoscales and regional climate variability. We focused mostly on studying the systematic errors for the multi-model ensemble results. The differences between the models have been also determined. The SGMIP multi-model ensemble results for the region compare well with reanalysis and observations, in terms of spatial and temporal diagnostics.

The major SGMIP results in terms of systematic errors are as follows:

1. Regional biases for time-averaged model products are mostly limited to about half (or less) of typical reanalysis or observational errors. Biases are larger, up to twice the reanalysis or observational errors (but only for the southern polar domain); note that our SGs have the North American area of interest. Overall, biases are within the uncertainties of the available reanalyses.

2. Both seasonal and interannual climate variability are well represented. Namely, annual cycles, seasonal differences, time series, and variances are close to those of observations or reanalyses.

3. Orographically induced precipitation and other products are well simulated at meso- and larger scales due to high-resolution regional forcing. The major positive regional impact from stretching is obtained from better resolved model dynamics and regionally-enhanced resolution of stationary lower-boundary forcing, i.e. orography and land-sea effects. In that sense, the improvements are obtained near small-scale terrain features and coastlines, and are reflected, for example, in the Appalachian and coastal precipitation.

Other SG-GCM results include the studies of systematic errors for: single model ensemble integrations (Fox-Rabinovitz et al. 2005), and the North American monsoon system (NAMS) for the multi-year time scales (Berbery and Fox-Rabinovitz 2003).

The future plans include: 1) conducting the phase-3 of the project, SGMIP-3, dedicated to simulation of future climate for the North American and other regions; and 2) contributing to the combined ensembles such as NARCCAP, including both nested and stretched grid models (using SGMIP-2 products for past climate and SGMIP-3 products for future climate).

The SGMIP results were presented to WMO/WGNE at its annual meetings in 2004, 2005, and 2006. The SGMIP products are available to national and international programs such as WMO/ WCRP/WGNE, CLIVAR, GEWEX, IPCC.

References

Fox-Rabinovitz, M. S., E. H. Berbery, L.L. Takacs, and R.C. Govindaraju, 2005: A multiyear ensemble simulation of the U.S. climate with a stretched-grid general circulation model?, *Mon. Wea. Rev.*, 133, pp. 2505-2525.

Fox-Rabinovitz, M.S., J. Cote, M. Deque, B. Dugas, J. McGregor, 2006: Variable-Resolution GCMs: Stretched-Grid Model Intercomparison Project (SGMIP), *J. Geophys. Res.*, 111, D16104, doi:10.1029/2005JD006520.

Berbery, E.H., and Fox-Rabinovitz, 2003: Multiscale diagnosis of the North American Monsoon System with a variable resolution GCM. *J. Climate*, 16, 1929-1947.

Hadley Circulation Changes under Global Warming

Primary Author: Gastineau, Guillaume

Additional Authors: Herve Le Treut

A Study on the Hadley Circulation Changes under Global Warming

The impact of greenhouse gas increase on the atmospheric large scale circulation is analyzed using Coupled General Circulation Model (CGCM) simulations carried out in the framework of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). The CGCM participating to the AR4 shows a weakening of the Hadley circulation for the winter cell in both hemisphere, accompanied with an increase of the extension of the Hadley circulation region. The increase of the extension and the weakening are stronger several years after the greenhouse gases concentration had been stabilized.

This weakening of the Hadley circulation is explained by two mechanisms using numerical values from the IPSL-CM4 model : first as a response to the SST changes, triggering a modification of the dry static stability of the tropical atmosphere, secondly as response to the baroclinicity changes in midlatitude that feedback on the tropical circulation.

Reference:

Gastineau G., H. Le Treut, L. Li, 2006: A study on the Hadley circulation changes under global warming to be submitted to journal of climate

Exploring the Utility of Metrics for the Evaluation of Climate Models

Primary Author: Gleckler, Peter

Additional Authors: Karl Taylor

Exploring the Utility of Metrics for the Evaluation of Climate Models

P. J. Gleckler and K.E. Taylor

In this poster we expand upon some of the key points made earlier the week (oral presentation, Taylor and Gleckler, "Uses of metrics in the evaluation and application of climate models"). Here we compute metrics for the tropics and extra-tropics separately, and address caveats such as how results can depend on the choice of the reference data-set. In addition to mean climate metrics, we explore basic measures of large-scale inter-annual variability, and then relate the two. Via example, we argue that indices intending to summarize overall model performance leave out important information, should be application dependent, and should be used cautiously. We further argue that the development of a hierarchy of metrics may be a more useful approach toward comprehensive model evaluation than trying to quantify model performance with a single scalar.

The Impact of Interdecadal Variability on the Skill of Climate Models

Primary Author: Grimm, Alice

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The Impact of Interdecadal Variability on the Skill of Climate Models

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Global climate models forced by sea surface temperature are standard tools in seasonal climate prediction and projection of future climate change. It has been shown that models' performance is seasonally dependent, but there has always been the assumption that, for a given season, it is constant. Here, we demonstrate that there are periods when those models perform well and periods when they do not capture observed climate variability. We compare the seasonal responses of two AGCMs to observed SST with seasonal observed fields during 1950-1994. The model performance is assessed through simultaneous correlation between reanalysis data and model output, averaged over 20° latitude Å~ 40° longitude regions. Seasonal correlations coefficients (CCs) are computed for winter and summer in 11-year sliding periods. The EOF analysis of these sliding CCs discloses the interdecadal variations of the models' skill all over the globe. The relationships between these variations and interdecadal modes of SST variability are examined by correlating SST with the two first Principal Components. The statistical significance is assessed through Monte Carlo procedure. The correlation patterns resemble closely those associated with well-known low-frequency variability (PDO and NAO), indicating that the modes of models' performance vary coherently with these interdecadal variability modes. These results suggest that there are un-modelled climate processes that affect seasonal climate prediction as well as scenarios of climate change, particularly regional climate-change projections. Their reliability may depend on the time slice being analyzed. More comprehensive assessments should include a verification of the long-term stability of the models' performance.

Acknowledgments. This work has been supported by the Interamerican Institute for Global Change Research (IAI -CRN055) and CNPq-Brazil.

Understanding El Nino Ocean-Atmosphere General Circulation Models

Primary Author: Guilyardi, Eric

Understanding El Niño in Ocean-Atmosphere General Circulation Models

Eric Guilyardi (LOCEAN/IPSL & NCAS Climate)

El Niño events represent major disruptions of the annual cycle of the tropical Pacific Ocean-atmosphere system on interannual timescales, with severe societal impacts on the whole planet. Predicting the characteristics of El Niño occurrence, amplitude and remote impacts for the next decades and centuries, is still a scientific challenge. State-of-the-art Ocean-Atmosphere General Circulation Models (OAGCMs) are advanced tools to both analyze El Niño mechanisms and predict its behavior on a range of timescales. Recent improvements show that El Niño is now an emergent model of variability in complex models. However, the diversity of their simulations of El Niño contributes to large uncertainty in projections. The recent multi-model approach, derived from the IPCC AR4, allows, to an unprecedented scale, latest generation OAGCMs to be analyzed together and compared. This requires new community efforts to develop appropriate metrics to assess the performance of individual models in reproducing El Niño events.

A Multi-Model Evaluation of Systematic Errors of the Tropical Seasonal Cycle in IPCC AR4 20th Century Simulations

Primary Author: Gualdi, Silvio

A Multi-Model Evaluation of Systematic Errors of the Tropical Seasonal Cycle in IPCC AR4 20th Century Simulations

S. Gualdi, A. Bellucci and A. Navarra

In this study, we examine the systematic errors in state of-the-art IPCC coupled general circulation models (CGCM). In particular, we focus on the seasonal cycle in the tropical region, an area where CGCMs typically fail in correctly reproducing the patterns of mean precipitation and SST (e.g., Lin 2006; submitted to J. of Climate). The 20th century from a subset of the IPCC AR4 simulations is analysed, by considering both atmospheric and oceanic fields. The purpose of this multi-model inter-comparison is to highlight the main biases affecting the mean seasonal variability in last generation climate models which are currently used to simulate climate scenarios and predict tropical variability and global teleconnections. In addition to a more traditional approach, we define several error indices, quantifying model biases (e.g., the double ITCZ), and try to relate them to the model ability in reproducing specific processes, such as, among the others, the monsoon and tropical/extra-tropical teleconnections. The role played by different parameterizations and horizontal/ vertical resolution on the mean seasonal cycle, is also analysed within the selected multi-model framework.

Results indicate that a proper simulation of tropical seasonal cycle is still far from being reached due to the presence of spurious double-ITCZ, anomalously westward extended cold tongue and missing upwelling in the eastern tropical Atlantic.

A Model Validation Strategy to Reduce the Persistent Spread in Projections of Future Climate

Primary Author: Hall, Alex

A Model Validation Strategy to Reduce the Persistent Spread in Projections of Future Climate

Alex Hall

UCLA

Divergence in simulations of climate feedbacks are sources of significant spread in climate models' temperature response to anthropogenic forcing. Here we map out a strategy for targeted observation of the climate system to reduce divergence in simulations of climate feedbacks, relying on the example of snow albedo feedback. The strength of this feedback in current models exhibits nearly a factor-of-three spread, which in turn accounts for much of the spread in the models' annual-mean temperature response in heavily-populated northern hemisphere land masses. These large intermodel variations in feedback strength in climate change are nearly perfectly correlated with comparably large intermodel variations in feedback strength in the context of the seasonal cycle. Moreover, the feedback strength in the real seasonal cycle can be measured and compared to simulated values.

These mostly fall outside the range of the observed estimate, indicating many models have an unrealistic snow albedo feedback in the seasonal cycle context. Because of the tight correlation between simulated feedback strength in the seasonal cycle and climate change, eliminating the model errors in the seasonal cycle will lead directly to a reduction in the spread of feedback strength in climate change. We also discuss the possibility of observational strategies to reduce the spread in other feedbacks contributing to climate sensitivity.

Forecasts of Southeast Pacific Stratocumulus with the NCAR, GFDL and ECMWF Models

Primary Author: Hannay, Cecile

Additional Authors: Dave Williamson, Jeff Kiehl, Jim Hack, Jerry Olson, Chris Bretherton, Steve Klein and Martin Koehler

Forecasts of Southeast Pacific Stratocumulus with the NCAR, GFDL and ECMWF Models

Cecile Hannay, Dave Williamson, Jeff Kiehl, Jim Hack, Jerry Olson, Chris Bretherton, Steve Klein and Martin Koehler.

We examine forecasts of Southeast Pacific Stratocumulus at 20S, 85W during the East Pacific Investigation of Climate (EPIC) cruise of October 2001 with the NCAR, NCAR-UW, GFDL and ECMWF models. The NCAR-UW is a modified version of the NCAR model that uses the turbulence and shallow convection schemes developed at the University of Washington.

Observations during the EPIC cruise show a very stable and well-mixed boundary layer under a sharp inversion. The inversion height and the cloud layer have a strong and regular diurnal cycle. The forecasts are initialized from atmospheric conditions and each model is run for 5 days to determine the drift from the field data. This method allows us to diagnose parameterization deficiencies. The atmospheric initial conditions are obtained from ECMWF analyses, which provide a good estimate of the EPIC column state, although the height of the PBL and the strength of the inversion are underestimated compared to the EPIC radiosonde data.

A key problem common to the 4 models is that the forecasted PBL height is too low compared to observations. The ECMWF model shows a steady PBL with no significant decrease or increase of the inversion height. The LWP and its diurnal cycle are represented very well in the ECMWF forecasts. In particular, the daytime LWP is well captured while the other models unrealistically collapse the LWP during daytime. This affects the solar flux at the surface. The ECMWF forecasts also have some deficiencies: it produces a cloud layer too thick compared to observations. The NCAR forecasts show 2 typical behaviors: either the PBL is maintained or it collapses, while the observations during the same period do not show any shallowing of the PBL. Climate runs with the NCAR model also show an inability to maintain the proper PBL depth. When the PBL collapses, the model becomes very moist near the surface. The cloud fraction is poorly represented: the model produces an unrealistically thick layer of clouds that sometimes extends to the surface. The diurnal cycle is underestimated. The NCAR-UW forecasts show a similar maintenance or collapse of the PBL. When the PBL is maintained, the clouds are more realistic than in the NCAR model, occupying a single level. The model also better represents the diurnal cycle of the inversion height due to the entrainment of dry air at the top of the PBL. When the PBL collapses, the cloud fraction and cloud water in NCAR-UW go to zero. The GFDL forecasts have periods during which the boundary layer becomes shallower. The collapse is less dramatic than in the NCAR forecasts but it is more pronounced than in the ECMWF ones. We also present SCM simulations with the NCAR and NCAR-UW models to better understand the mechanisms that control the PBL.

Elucidating Model Inadequacies in a Cloud Parameterization by use of an Ensemble-Based Calibration Framework

Primary Author: Hansen, J.A.

Additional Authors: Jean-Christophe Golaz and Vince E. Larson

Elucidating Model Inadequacies in a Cloud Parameterization by use of an Ensemble-Based Calibration Framework

James A. Hansen, NRL

Jean-Christophe Golaz, GFDL

Vince E. Larson, University of Wisconsin - Milwaukee

Parameterizations contain structural inadequacies. The source of these inadequacies is difficult to pinpoint because parameterizations contain nonlinearities and feedbacks. To help elucidate such model inadequacies, this presentation demonstrates the use of a general purpose ensemble parameter estimation technique. In principle, the technique is applicable to any parameterization that contains a number of adjustable coefficients. It optimizes or calibrates parameter values by attempting to match predicted fields to reference datasets. Rather than striving to find the single best set of parameter values, the output is instead an ensemble of parameter sets. This ensemble provides a wealth of information. In particular, it can help uncover model deficiencies and structural errors that might not otherwise be easily revealed. The calibration technique is applied to an existing single-column model (SCM) that parameterizes boundary-layer clouds. The SCM is a higher order turbulence closure model. It is closed using a multi-variate probability density function (PDF) that represents subgridscale variability. Reference datasets are provided by large-eddy simulations (LES) of a variety of cloudy boundary layers. The calibration technique locates some model errors in the SCM. As a result, empirical modifications are suggested. These modifications are evaluated with independent datasets and found to lead to an overall improvement in the SCM's performance.

Validation of AR4 Models for the New York City Watershed Region

Primary Author: Horton, Radley

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Validation of AR4 Models for the New York City Watershed Region

Radley Horton, Cynthia Rosenzweig, and David C. Major

We are using output from five AR4 CGCMs run with three SRES emissions scenarios to generate probabilistic climate change scenarios for the New York City watershed region. As a first step, results from the climate of the 20th Century, as well as downscaled results with the NCAR MM5 RCM, are compared to observed gridded precipitation and temperature data (New et al. 1999) from 1970 to 1999. At the annual scale, the multi-model ensemble results are within 1 C of observed temperature and 5 percent of observed precipitation, although individual model results are mixed. At finer temporal scales, additional model biases are evident, including: 1) insufficient temporal variability at daily timescales, and 2) a cold bias during winter. The monthly RMSE results over the region indicate that among the models selected, NCAR CCSM 3.0 and GFDL 2.1 show the most skill. Our results suggest that hindcast runs with these CGCMs are of sufficient accuracy to justify their inclusion as key components in regional climate change scenarios.

The Interaction of the Madden-Julian Oscillation and the Maritime Continent in a GCM

Primary Author: Inness, Peter

Additional Authors: Julia Slingo

The Interaction of the Madden-Julian Oscillation and the Maritime Continent in a GCM

Peter Inness and Julia Slingo

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As the Madden-Julian Oscillation (MJO) passes over the islands of the Maritime Continent it is observed to weaken somewhat before reinvigorating over the West Pacific. However, studies with the HadCM3 coupled GCM showed that the MJO tends to die out altogether over this region, with very few cases of active MJO convection propagating from the Indian Ocean to the West Pacific. In this study, the effect of the topography of the Maritime Continent islands acting to disrupt the low level wind and pressure signal associated with the MJO is investigated. An idealised modelling framework is used in which an eastward propagating SST anomaly dipole is used to force organised convection which resembles the MJO. It is found that, although the island topography in the GCM is very much lower than in reality, it has a disproportionately large impact on the low level winds and pressure trough to the east of the convective maximum of the MJO. In particular the representation of Sumatra as a single gridpoint wide, north-south oriented barrier seems to be central to the killing off of the MJO as it passes over the region in this GCM.

Systematic Error Growth Rate in the mm5 Model

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Systematic Error Growth Rate in the mm5 Model

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The goal of this work is to estimate model error growth rates in simulations of the atmospheric circulation by the MM5 model all the way from the short range to the medium range and beyond. The major topics are addressed to: (i) search the optimal set of parameterization schemes; (ii) evaluate the spatial structure and scales of the model error for various atmospheric fields; (iii) determine geographical regions where model errors are largest; (iv) define particular atmospheric patterns contributing to the fast and significant model error growth. Results are presented for geopotential, temperature, relative humidity and horizontal wind components fields on standard surfaces over the Atlantic-European region during winter 2002. Various combinations of parameterization schemes for cumulus, PBL, moisture and radiation are used to identify which one provides a lesser difference between the model state and analysis. The comparison of the model fields is carried out versus ERA-40 reanalysis of the ECMWF. Results show that the rate, at which the model error grows as well as its magnitude, varies depending on the forecast range, atmospheric variable and level. The typical spatial scale and structure of the model error also depends on the particular atmospheric variable. The distribution of the model error over the domain can be separated in two parts: the steady and transient. The first part is associated with a few high mountain regions including Greenland, where model error is larger. The transient model error mainly moves along with areas of high gradients in the atmospheric flow.

Acknowledgement: This study has been supported by NATO Science for Peace grant #981044. The MM5 modelling system used in this study has been provided by UCAR. ERA-40 re-analysis data have been obtained from the ECMWF data center.

A Cascade Type of Energy Conversion Diagram Based on Mass-Weighted Isentropic Zonal Means and Its Application to Model Diagnosis

Primary Author: Iwasaki, Toshiki

A Cascade Type of Energy Conversion Diagram Based on Mass-Weighted Isentropic Zonal Means and Its Application to Model Diagnosis

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Diagnostic scheme of global energetics based on mass weighted isentropic zonal means is proposed to analyze climate variability. The mass-weighted isentropic zonal mean is capable of a full expression of wave-mean-flow interactions, including the lower boundary values. It also leads us to very different energy conversion diagram from the conventional four-box model. The energy flow can be represented in a cascade from the zonal mean available potential energy (P_z) to the wave energy (W) via the zonal mean kinetic energy (K_z). By using the new diagnosis package, we diagnose GCM climate and compare it with reanalyses.

References

- S. Uno and T. Iwasaki, 2006; A Cascade type global energy conversion diagram based on wave-mean-flow interactions. J. Atmos. Sci. (in press)
- D. Tanaka, T. Iwasaki, S. Uno, M. Ujiie and K. Miyazaki, 2004; Eliassen-Palm flux diagnosis based on isentropic representation, J. Atmos. Sci., 61,2370-2383.
- T. Iwasaki, 2001: Atmospheric energy cycle viewed from wave, mean-flow interaction and Lagrangian mean circulation, J. Atmos. Sci.,58,3036-3052.

Impacts of Systematic Error Reduction on CAM3.1 Sensitivity to CO₂ Forcing

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Impacts of Systematic Error Reduction on CAM3.1 Sensitivity to CO₂ Forcing

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The current disparity that exists among models of the climate system in their response to projected increases in greenhouse gases provides a measure of uncertainty in the model development process. A large part of this uncertainty is likely related to specification of model parameters. We estimate a lower bound to this part of the uncertainty as may be inferred from an ensemble of model configurations made from a single model (the NCAR CAM3.1 atmospheric GCM). The choice of ensemble members is constrained by a stochastic, Bayesian based, importance sampling strategy whose likelihood function includes a normalized, multivariate measure of model skill that quantifies the distance among seasonal climatologies of model predictions and fifteen observational/reanalysis data products. We consider the effects of six parameters important to clouds and convection. The top six performing parameter sets improved model skill by 7% with nearly identical skill scores, but for different reasons related to the wide range of selected parameter values. These model configurations were chosen for estimating the effect of parametric uncertainties on the predicted global warming response to 2xCO₂. Five of the six model configurations had a 2xCO₂ near surface air temperature sensitivity of 3 or 3.1 degrees with the final member having a sensitivity of 3.4 as compared to the 2.4 degree sensitivity of the default model configuration. Although the range in sensitivities was quite narrow after parameter values have been systematically constrained by observations, the regional climate predictions exhibited significant uncertainties up to 25% of the climate change signal for predictions of surface air temperature and up to 160% of the signal for precipitation. This calculation demonstrates the potential of using observations to substantially reduce climate model prediction uncertainties with a more formal method of multivariate model tuning. It also provides an estimate of the upper bound for single-model prediction skill, particularly for regional climates.

Sensitivity of the Simulated Atmospheric Circulation to Horizontal Resolution: From Climate to NWP Resolution

Primary Author: Jung, Thomas

Additional Authors: Tim Palmer and Frederic Vitart

Sensitivity of the Simulated Atmospheric Circulation to Horizontal Resolution: From Climate to NWP Resolution

Thomas Jung, Tim Palmer and Frederic Vitart
ECMWF

The latest version of the ECMWF model is used to study the sensitivity of various simulated atmospheric phenomena to horizontal resolution. Four different horizontal resolutions are considered: TL95 (180km), TL159 (120km), TL255 (80km) and TL511 (40km). Results are based on seasonal forecast experiments with prescribed SSTs for both summers and winters of the period 1990-2005. In the North Atlantic and North Pacific, increasing horizontal resolution to T511 leads to significant improvements in simulated blocking frequencies. Moreover, it turns out that increasing resolution results in a much better representation of both extratropical and tropical cyclone characteristics (e.g., frequency of occurrence of hurricanes of different intensity). However, there are also model problems, such as the realistic simulation of the MJO, which remain unchanged even if resolution is increased to TL511.

Evaluation of Precipitation Extremes Simulated by a Global 20-km-grid Atmospheric Model using L-moments Method

Primary Author: Kamiguchi, Kenji

Evaluation of Precipitation Extremes Simulated by a Global 20-km-grid Atmospheric Model using L-moments Method

Kenji Kamiguchi (MRI, Japan)

Prediction of future change in extreme precipitation is very important and challenging study. Long time integration with high resolution model is required to do that. In this study, the annual maximum of daily precipitation (AMDP) simulated by a global 20-km-grid atmospheric model is evaluated by the rain gauge observation using L-moments method which is an excellent technique for extreme analysis.

The model used here is MRI-AGCM (Atmospheric General Circulation Model) whose horizontal resolution is 20-km. An AMIP climate simulation is conducted for 20-year.

L-moments are calculated in each grid using 20 samples of the AMDP. Meanwhile, rain gauge data contained in GDCN (Global Daily Climatology Network) is used as an observation. L-moments of the observation are calculated for the rain gauge stations whose observation length is the same or longer than 20-year. Though I recognize that there is room for further discussion about adequacy of direct comparison between grid value and station value, grid value is compared with station value at correspondent location.

The geographical pattern of the first order of L-moment (arithmetic mean of samples) in the model is in good agreement with that of the observation, reflecting realistic topography in the model.

However, value is smaller than the observed ones. As the third and the forth order of L-moment (called L-skewness and L-kurtosis, respectively) are plotted on L-moments diagram, the probability distribution function (PDF) of the AMDP roughly conforms to Gumbel distribution, both in the model and in the observation.

However, in the observation, there are many places whose L kurtosis and L-skewness are larger than that of the model.

Tropical Rainfall Diurnal Cycle in a 20km-mesh Atmospheric GCM

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Tropical Rainfall Diurnal Cycle in a 20km-mesh Atmospheric GCM

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Tropical rainfall diurnal variation simulated by 20km-mesh atmospheric GCM (GCM-TL959) and its lower-resolution version (190km-mesh GCM-TL95) are investigated by comparing with the Tropical Rainfall Measuring Mission (TRMM) 3G68 V6 data. Both GCMs were integrated for 10 years after spin-up with the observed monthly mean sea surface temperature (SST) and sea ice distribution climatology. For annual mean rainfall diurnal cycle, diurnal rainfall amplitude in GCM-TL959, defined by peak to-trough rainfall difference, is larger than that in TRMM 3G68 data over both land and the ocean. The local time of maximum rainfall in GCM-TL959 is 1-2 hour earlier than that in TRMM 3G68 data over both land and the ocean. However, there are large differences in simulated peak time with the TRMM 3G68 data over some region such as the southern slope of the Himalayas and Congo basin, equatorial Africa. Comparison between GCM-TL95 and GCM TL959 shows little difference both diurnal phase and amplitude. These results show that spatial resolution has little impact on simulation of rainfall diurnal cycle in GCMs and indicate importance of parameterization for physical processes.

What Can Climate Modelers Learn from a Weather Forecasting Approach about Errors in the Parameterization of Atmospheric Moist Processes?

Primary Author: Klein, Steve

Additional Authors: Jim Boyle, Shaocheng Xie, Jerry Potter, Tom Phillips, Justin Hnilo, and David Williamson (NCAR)

What Can Climate Modelers Learn from a Weather Forecasting Approach about Errors in the Parameterization of Atmospheric Moist Processes?

Stephen A. Klein (LLNL)

Co-authors: Jim Boyle, Shaocheng Xie, Jerry Potter, Tom Phillips, Justin Hnilo, and David Williamson (NCAR)

The ability to assess the parameterizations of moist processes by performing weather forecasts with climate models is discussed. The advantages include an assessment of the moist processes as a function of the observed atmospheric state, an increased ease of using field experiment data, and identification of errors before longer time scale biases develop. Examples are provided using simulations with the NCAR and GFDL climate models. While the results do not always unambiguously identify parameterization errors, the results are strong enough to recommend that a weather forecasting approach should be a technique regularly available to evaluate new parameterizations of atmospheric moist processes.

The Effect of High-Frequency, Observed SST Forcing on AGCM Simulations of Indian Monsoon Intraseasonal Variability

Primary Author: Klingaman, Nicholas

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The Effect of High-Frequency, Observed SST Forcing on AGCM Simulations of Indian Monsoon Intraseasonal Variability

Nicholas P. Klingaman (1), Peter M. Inness (1), Julia M. Slingo (1), Hilary Weller (1)

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The Indian summer monsoon provides much of the subcontinent's annual precipitation and is an essential moisture source for agricultural production. While the monsoon exhibits substantial interannual variations, its intraseasonal variability is of greater magnitude and hence of critical importance for predictability. This intraseasonal variability is concentrated in the 30-50 day band and comprises a northwards-propagating oscillation(NPISO) between active and break phases of enhanced and reduced precipitation over India, while the opposing phase dominates over the equatorial Indian Ocean.

Recent investigations using general circulation models(GCMs) have suggested that the NPISO is an intrinsically atmospheric mode, but that atmosphere-ocean coupling is required to achieve realistic intensity and propagation speed. Specifically, coupled GCMs (CGCMs) outperform atmosphere-only GCMs (AGCMs) due to the CGCMs ability to represent the near-quadrature phase relationship between sea-surface temperatures (SSTs) and atmospheric deep convection. Without atmosphere-ocean feedbacks, AGCMs too quickly initiate convection over warm SST anomalies. These studies have forced their AGCM simulations with SSTs from either a previous CGCM simulation or the NCEP (Reynolds) satellite SST product, however, both of which substantially underestimate intraseasonal SST variability across the tropical Indian Ocean.

In this study, we have forced the Hadley Centre Atmospheric Model (HadAM3) with a new, high-frequency, observed SST dataset from the UK Met Office. These SSTs show significantly more variability in the intraseasonal band than the existing NCEP dataset. Two thirty-member ensembles have been conducted at 1 degree spatial resolution: one forced by daily SSTs and the other forced by monthly mean SSTs. These ensembles are compared to determine whether high-frequency, realistic SSTs can improve AGCM simulations of the intraseasonal variability of the Indian monsoon. Composite active and break events are constructed from each ensemble and compared to similar composites taken from reanalysis to examine the degree to which each ensemble properly represents the physical mechanisms underlying the NPISO.

The North American Monsoon in the AR4 20C3M Simulations

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The North American Monsoon in the AR4 20C3M Simulations

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We are conducting a diagnostic analysis of model simulations regarding their ability to reproduce the surface climatic features and tropospheric circulation features of the North American Monsoon (NAM). We have identified key circulation features correlated with the interannual variability of June-September precipitation in the core NAM area of Mexico. We are analyzing all of the available 20C3M simulations produced for the IPCC Fourth Assessment Report, comparing observed correlation patterns with those produced by the model. Preliminary diagnosis shows that most CGCMs fail to produce key characteristics of the NAM precipitation annual cycle and interannual variability and their links to the planetary circulation. Yet certain models do capture some of these key characteristics. We will present a more complete diagnosis of the common model failures and outstanding successes in simulating the NAM precipitation variability.

Performance of a 20-km mesh Global Atmospheric Model in a AMIP-type Experiment

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Performance of a 20-km mesh Global Atmospheric Model in a AMIP-type Experiment

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The Japan Meteorological Agency (JMA) and the Meteorological Research Institute (MRI) have developed a global hydrostatic atmospheric model with a 20-km grid size. The time integration was accelerated by introducing a semi-Lagrangian three-dimensional advection scheme. The model has a horizontal spectral truncation of TL959 corresponding to about a 20-km horizontal grid spacing and has 60 levels with a 0.1 hPa (altitude of about 65 km) top. We have conducted an Atmospheric Model Intercomparison Project (AMIP)-type experiment in which the model was forced with observed sea surface temperature from January 1979 through February 2006. The integration of the 20-km model and data processing were performed on the Earth Simulator. The performance of model with respect to climatology and year-to-year variability will be presented as well as the reproducibility of specific abnormal weather condition such as the hot summer of 2003 over Europe.

Simulation of High Latitude Climate

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Simulation of High Latitude Climate

Byrkjedal, I. Esau and N. G. Kvamsto

The current general circulation models, including several of those used by the IPCC, show considerable disagreement in simulating present day high latitude climate. This is of major concern and reduces the confidence in future model projections of high latitude climate. The wintertime Arctic climate is characterized by a very shallow stable planetary boundary layer (from a few tenths to a couple hundred meters deep). The boundary layer is capped by a strong inversion. The lowest temperatures are found near the surface while the maximum temperature is found at the top of the inversion, typically at 500-1500 meters. The boundary layer turbulent activity is inhibited by the very stable atmospheric conditions. The very low turbulent activity may cause very low surface temperatures to form. To investigate how turbulent vertical exchange processes in the Arctic boundary layer is represented by the climate models a simulation with high vertical resolution in the lower part of the atmosphere is performed. This reveals that the coarse vertical resolution commonly employed in the climate models are unable to reproduce important exchange processes in the Arctic boundary layer. In the case of our model this results in a warm bias over the Arctic Ocean. By increasing the vertical resolution we achieve a better representation of vertical turbulent exchange processes with the result of reproducing more realistic surface fluxes and surface air temperatures.

Simulation of the Great Plains Low-level Jet in the AR4 Coupled GCMs

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Simulation of the Great Plains Low-level Jet in the AR4 Coupled GCMs

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The realism of the simulation of an important dynamical feature of the summertime climate of the Midwestern U.S., the Great Plains low level jet (GPLLJ), is evaluated in 18 coupled GCM simulations of the 20th century. The modeled time-mean jet and its variability, as well as its relationship to precipitation and surface moisture, are compared with two reanalysis products - the NCEP/NCAR reanalysis (with similar resolution to the GCMs) and the North American Regional Reanalysis (with finer resolution than GCMs) - to select models with reasonable representations. Simulations of the 21st century from a few models with more realistic simulations of the GPLLJ are examined to evaluate possible changes in the jet under various forcing scenarios, and the relationship of those changes to any changes in Midwest hydrology. A multi-scale analysis will be used to evaluate the extent to which the GPLLJ acts to communicate the global-scale warming signal, and/or SST increases in the tropical Atlantic and Gulf of Mexico, into small-scale precipitation systems over the Central Plains.

Evaluation of Ice Biases in a Global Coupled (0.4 degrees) Ocean/Sea Ice-Model

Primary Author: Ivanova, Detelina

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Evaluation of Ice Biases in a Global Coupled (0.4 degrees) Ocean/Sea Ice-Model

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Model biases in a moderately fine-resolution (0.4 degrees, 40 vertical levels), global coupled ice-ocean model are evaluated by statistical comparisons with available observational data sets. The model consists of the Los Alamos National Laboratory Parallel Ocean Program (POP) and the thermodynamic-dynamic sea ice model known as CICE. The model simulation was run for 23 years (1979-2002), largely forced with high-frequency National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) atmospheric fluxes. Following a decade-long spin-up of the ice model, the fidelity of the ice extent, ice thickness, and ice drift distributions is examined. The model realistically simulates the space and time distributions of the global sea ice cover concentration, thickness and drift. The total ice area and extent agree well with Special Sensor Microwave/Imager (SSM/I) satellite data especially in the winter season in the Arctic and summer season in the Antarctic; overall the model quantities are larger by about 10% in the Arctic and 17-20% in the Antarctic suggesting that the model is reproducing well the observed seasonal cycles of ice extent and area. In the Weddell Sea, simulated ice thickness is compared with moored upward looking sonar data. At the locations of the open-ocean moorings, the agreement is good but it is less accurate near to the Weddell Peninsula. Statistics of ice drifting buoy observations agree well with temporally and spatially co-located simulated ice drifts both in terms of speed and direction. The model ice drift speed distribution tends to be dominated by slower speed ranges than that of the observations.

Estimating and Correcting Model Errors in the Ensemble Kalman Filter

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Estimating and Correcting Model Errors in the Ensemble Kalman Filter

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The main goal of this work is to investigate techniques for treating model errors in the ensemble Kalman filter, and to develop a data assimilation system capable of assimilating real weather observations. An ensemble based data assimilation scheme - local ensemble transform Kalman filter (LETKF, Hunt et al. 2006) is applied to the SPEEDY primitive equation global model (Molteni 2003). The model errors are introduced by assimilating observations from the NCEP/NCAR reanalysis data. The effect of model errors on LETKF is investigated. To deal with the model error, several model error correction methods are tested, including the 'covariance inflation', the Danforth et al(2006) low-order method, the Dee and da Silva method (1998) and its simplified version (Radakovich et al 2001). The performances of these methods are investigated and compared under the different observational networks.

Intercomparison of the Northern Hemisphere Winter Mid-Latitude Atmospheric Variability of the IPCC Models by Wave Activity Performance Metrics

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Intercomparison of the Northern Hemisphere Winter Mid-Latitude Atmospheric Variability of the IPCC Models by Wave Activity Performance Metrics

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We estimate the northern hemisphere mid-latitude winter atmospheric variability within the available XX century (1961-2000) and 720 CO₂ ppm stabilization (2181-2200) simulations of the GCMs included in the IPCC-4AR. We compute the Hayashi spectra of the 500hPa geopotential height fields and introduce an ad hoc integral measure of the variability observed in the Northern Hemisphere on different spectral sub-domains. The total wave variability is taken as a global scalar metric describing the overall performance of each model, while the total variability pertaining to the eastward propagating baroclinic waves and to the planetary waves are taken as scalar metrics describing the performance of each model phenomenologically in connection with the corresponding specific physical process. When considering the XX century simulations, only two very high-resolution global climate models have a good agreement with the NCEP-NCAR and ECMWF reanalyses for both the global and the process-oriented metrics. Large biases, in several cases larger than 20%, are found in all the considered metrics between the wave climatologies of most IPCC models and the reanalyses, while the span of the climatologies of the various models is, in all cases, around 50%. In particular, the travelling baroclinic waves are typically overestimated by the climate models, while the planetary waves are usually underestimated, in agreement with what found in past analyses performed on global weather forecasting models. When comparing the results of similar models, it is apparent that in some cases the vertical resolution of the model atmosphere, the adopted ocean model, and the advection schemes seem to be critical in the bulk of the atmospheric variability. The models ensemble obtained by arithmetic averaging of the results of all models is biased with respect to the reanalyses but is comparable to the best 5 models. Nevertheless, the models results do not cluster around their ensemble mean. When considering the XXII century simulations, the first notable change is that in all cases the spectral densities tend to shift towards longer waves. Relatively small changes are observed in all GCMS for the global scalar metric. In virtually all GCMs eastward propagating baroclinic waves increase (up to about 20%), even if disagreement exist on the amount of the change, whereas for the long standing waves not all GCMs agree on the sign of the change. In general, GCMs with low variability in the 1961-2000 run tend to have less pronounced sensitivity with respect to climate forcing. This study suggests caveats with respect to the ability of most of the presently available climate models in representing the statistical properties of the global scale atmospheric dynamics of the present climate and, a fortiori, in the perspective of modeling climate change.

Mid-Latitude Atmospheric Regimes, Subtropical Jet, and ENSO

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Mid-Latitude Atmospheric Regimes, Subtropical Jet, and ENSO

Valerio Lucarini, Sandro Calmanti, Alessandro Dell'Aquila, Paolo M. Ruti, Antonio Speranza

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Understanding the atmospheric low-frequency variability is of crucial importance in fields such as climate studies, climate change detection, and extended range weather forecast. The Northern Hemisphere climate features the planetary waves as a relevant ingredient of the atmospheric variability. Several observations and theoretical arguments seem to support the idea that winter planetary waves indicator obey a non-Gaussian statistics and may present a multimodal probability density function, thus characterizing the low-frequency portion of the climate system. We show that the upper tropospheric jet strength is a critical parameter in determining whether the planetary waves indicator exhibits a uni- or bimodal behavior, and we determine the relevant threshold value of the jet. These results are obtained by considering the data of the NCEP/NCAR and ECMWF reanalyses for the overlapping period. Our results agree with the non-linear orographic theory, which explains the statistical non-normality of the low-frequency variability of the atmosphere and its possible bimodality. Moreover, since the intensity of the jet is related to the ENSO phase, these results show a connection between the tropical and the mid-latitude climate. Data coming from the 1961-2000 simulations performed by two very high-resolution global climate models, which have been previously shown to represent very well the overall properties of the Northern Hemisphere mid-latitude winter atmospheric variability, match only partially this picture, thus providing some hints on models inaccuracy in representing large scale features.

Investigating the Influence of Systematic Biases on the Annual Cycle and ENSO Variability in the Coupled GCMs Using Flux Correction Method

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Investigating the Influence of Systematic Biases on the Annual Cycle and ENSO Variability in the Coupled GCMs Using Flux Correction Method

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A series of coupled GCM experiments are conducted to test the hypothesis that the existence of systematic biases in the Tropics could have serious consequences for the quality of model-simulated variability on various temporal-spatial scales. To reduce annual mean errors in the coupled models, an empirical method is used in this study, such as the flux adjustment strategy, in which a prescribed correction term is added to the surface heat flux into the ocean. This correction term varies spatially but is constant in time, and its magnitude is proportional to the annual mean local SST error in the directly coupled GCM integration. By design, it only affects the mean surface heat balance directly. It must be noted that in this study we intentionally keep the flux correction at a minimum and target those errors with relatively clear physical error sources. In the first part of our study the above heat flux correction method is applied in the Tropics, and is implemented in the coupled GCM, where the atmospheric component is the Center for Ocean-Land-Atmosphere Studies (COLA) AGCM (Version 2) and the oceanic component is a quasi-isopycnal reduced-gravity OGCM. As expected, this constant heat flux correction eliminates most large mean SST errors in the directly coupled run, including the warm bias in the southeast Pacific and Atlantic. As a result, the corrected mean climate exhibits stronger SST asymmetry relative to the equator. It is found that, given better mean SST field, mean distributions of surface wind stress and precipitation are also improved in these regions. Due to the improvement of the model mean state, the annual cycles of the SST and surface wind stress in the eastern equatorial Pacific become more realistic as a result of enhancement of their annual, rather than semi-annual, harmonics. The annual cycle of precipitation in the eastern Pacific is also improved due to more realistic seasonal SST variations in this region. Both directly coupled and the flux corrected models simulate interannual variability in the tropical Pacific with some ENSO characteristics. However, in the first version phase locking of ENSO to the annual cycle is unrealistic. In the second, phase locking is well reproduced, likely due to more realistic seasonal evolution of the mean state. The development of ENSO events at the equator and tropical teleconnections are also more realistic. On the other hand, the simulated interannual variability is weaker and the timescale of ENSO cycle is longer in both runs compared to observations, but more so in the flux corrected simulation. In the second part of our study we apply the heat flux correction method to the NCEP Climate Forecast System (CFS), which is a state-of-the-art fully coupled ocean-land-atmosphere dynamical seasonal prediction system for operational forecasts. In the first experiment, heat flux correction is applied to the whole tropical oceans. In the second, it is further localized to include only the southeast Pacific and Atlantic, where the SST bias is the largest. Preliminary analysis shows that the mean SST errors in the southeast Pacific and Atlantic are significantly reduced in both experiments. As a result of stronger SST gradient, equatorial easterlies are significantly enhanced and are closer to the observed, which is likely responsible for the deepened equatorial thermocline. On the other hand, heat content and SST variability in the tropical Pacific is weaker in both runs compared to the directly coupled model simulation and the observations. However, the ENSO cycle is less regular, and the duration of ENSO episodes is shortened and more in line with the observed variability. Experiments with the uncoupled version of the Modular Ocean Model Version 3 (MOM3), which is the oceanic component of the CFS, are currently underway to test the hypothesis that the deepening of the equatorial thermocline in response to more realistic zonal wind stress has effectively weakened ENSO variability in the model. In addition, we are currently introducing global wind stress correction into the CFS to test whether correcting wind stress, as opposed to SST, is a more efficient way to improve the simulation of the mean climate and ENSO variability.

Modelling the Stratosphere in Coupled Atmosphere Ocean Models: Systematic Changes in Mean Climate

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Modelling the Stratosphere in Coupled Atmosphere Ocean Models: Systematic Changes in Mean Climate

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The systematic influence of the stratosphere on the modelling of the coupled atmosphere ocean climate system is investigated by analyzing two sets of simulations. The first set consists of two AMIP simulations, one with a low top (ECHAM5) and the other with a high top (MAECHAM5) atmospheric general circulation model. For the second set, two simulations are considered: one with the low and the other with the high top atmosphere model, respectively coupled to an ocean general circulation model. The AMIP simulations are 21 years long. The coupled simulations are each 100 year long. By intercomparing the AMIP and coupled simulations, a general increase in the tropospheric temperature is found for the high top model. The causes and the direct and indirect (via the coupling to the ocean) effects of the atmospheric model top on the simulated mean climate are thereafter assessed.

A MISR Simulator for GCM Clouds: Cloud Top Height and Optical Depth Histograms from ISCCP and MISR

Primary Author: Marchand, Roger

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A MISR Simulator for GCM Clouds: Cloud Top Height and Optical Depth Histograms from ISCCP and MISR

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Joint histograms of Cloud Top Height (CTH) and Optical Depth (OD) derived by the International Satellite Cloud Climatology Project (ISCCP) are being widely used by the climate modeling community in evaluating global climate models. Similar joint histograms of CTH-OD are now being produced by the NASA Multi-angle Imaging Spectro Radiometer (MISR) and Moderate Resolution Imaging Spectroradiometer (MODIS) instrument teams. There are notable differences in the histograms being produced by these three projects. In this presentation we analyze some of the differences and discuss how the differences relate to the retrieval approaches used and what they tell us about the observed cloud fields.

Many comparisons between ISCCP and climate models use the ISCCP simulator constructed by Steve Klein and Mark Web. We have constructed a MISR simulator, similar in structure to this ISCCP simulator. In this presentation we will use our MISR simulator to compare output from the Multiscale Modeling Frame (MMF) climate model of Khairoutdinov and Randall with MISR retrievals. We plan to make the MISR simulator available to the scientific community and will provide information on how to obtain a copy and use the simulator at the end of the presentation.

Analysis and Reduction of Climate Model Systematic Errors through a Unified Modelling Strategy

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Analysis and Reduction of Climate Model Systematic Errors through a Unified Modelling Strategy

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Various techniques are used in understanding and reducing climate model systematic errors. These include the use of idealised models (single column model, aqua planet, dynamical core), sensitivity tests designed to shed light on processes and investigate teleconnections, and "spin-up" tests which allow us to determine whether a systematic bias is the result of long-term feedbacks, e.g. through model drift, or an immediate movement of the model away from the initial observed state and from which it does not recover. In the latter case, it may be possible to attribute the source of the error to a particular parametrisation scheme, thus making its solution potentially rather easier. Spin-up tests using climate models also provide a parallel with numerical weather prediction models, which themselves have the benefit of assimilated observations as well as (usually) higher resolution.

At the Met Office, the same model is used for both daily forecasting and climate prediction, allowing direct comparison between the two systems. Each system brings a unique perspective to model development. The use of state of-the-art variational data assimilation in the forecast model minimises the errors in the large-scale synoptic flow and can allow parametrisation errors to be identified more easily. In addition, comparisons can be made against detailed observational datasets (ARM, TOGA-COARE, GCSS) to investigate individual physical processes. Long climate runs show how a parametrisation behaves in equilibrium and in combination with the rest of the model physics and dynamics. Coupled climate modelling represents a stringent test of the model physics as systematic errors in the atmosphere can feed back on the ocean. Although it is not always the case that model systematic errors are shared between the daily forecast model and the climate model, when this is the case we find that a unified approach to model development is beneficial to both systems.

Examples of the use of our joint approach to analysing and reducing systematic errors in the Met Office Unified Model are described, with particular reference to the representation of ENSO and the Asian summer monsoon in HadGEM1. Further examples are given in a contribution by Milton et al..

Systematic Errors in El Nino Teleconnections and Associated Extreme Events over North America

Primary Author: Meehl, Gerald

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Systematic Errors in El Nino Teleconnections and Associated Extreme Events over North America

Gerald A. Meehl, Claudia Tebaldi, Haiyan Teng and Julie Arblaster
NCAR

Systematic errors in El Nino teleconnections over North America in global coupled climate models are shown to be manifested as errors in the associated patterns of extremes. Typically, the anomalously deepened Aleutian Low that occurs during El Nino events in northern winter is shifted westward in association with centers of equatorial SST anomalies, precipitation and convective heating anomalies that are also positioned too far west in the model El Nino events. Therefore, in comparison to observed patterns of extremes during El Nino events, there are comparable systematic errors in the simulated extremes over North America. These errors are shown to be relevant to interpretation of possible future changes of extremes in climate change projections.

Systematic Errors in Parametrizations in Global NWP : Evaluation Against Observational Data and Budget Studies

Primary Author: Milton, Sean

Additional Authors: Glenn Greed, Malcolm Brooks, Paul Earnshaw, Martin Willett & David Walters

Systematic Errors in Parametrizations in Global NWP: Evaluation Against Observational Data and Budget Studies

Sean Milton, Glenn Greed, Malcolm Brooks, Paul Earnshaw, Martin Willett & David Walters.
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There are key advantages to using short-range NWP forecasts to study model systematic errors. Individual weather systems and their physical processes can be evaluated against detailed observational datasets (ARM, AMMA, TOGA-COARE etc.). Secondly, the systematic drift of the forecasts from the analysed state can be studied in detail in terms of budgets of heat, momentum, moisture and potential vorticity (PV). In the short-range (0-2 days) this can highlight local errors in parametrized or dynamical processes before errors arising from remote forcing make attribution difficult. The Met Office global NWP version of the Unified Model is close in formulation to that used for climate prediction, providing an ideal testbed for investigating errors in parametrized processes and their relationship to longer term systematic error growth (see contribution from Martin & co-authors for more discussion of climate aspects and idealised modelling). We focus here on examples from recent studies of systematic errors in NWP which use a combination of observational data and budget studies. These include some of the following (i) A continental summer warm bias in the extratropics investigated using observations from the ARM site at Southern Great Plains, (ii) West Africa - surface fluxes from the ARM mobile facility (situated in Niamey during the AMMA campaign of 2006) and radiative fluxes from the GERB instrument on Meteosat-8 are used to examine systematic errors in the surface energy and radiative balance during the dry and monsoon seasons. One key deficiency for this region is a lack of predictive capability for mineral dust aerosol. The performance of a dust parametrization developed for the climate model is evaluated in NWP mode, and (iii) Monsoons - the drift from analyses in the model's PV, thermal and momentum budgets are used to study the impact of potential deficiencies in parametrized processes on the evolution of the Monsoon flows and hydrological cycle over India and West Africa.

A Comparison of Climate Prediction and Simulation over Tropical Pacific

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A Comparison of Climate Prediction and Simulation over Tropical Pacific

Vasubandhu Misra, L. Marx, M. Fennessy, B. Kirtman, J. L. KinterIII

In this study we compare an ensemble of seasonal hindcasts with a multi-decadal integration from the same global coupled climate model over the equatorial Pacific Ocean. It is shown that the annual mean state of the SST and its variability are different over equatorial Pacific Ocean in the two operating modes of the model.

These differences are a manifestation of a more inherent difference in the physics of coupled air-sea interactions and upper ocean variability. It is argued that in the presence of large coupled model errors and in the absence of a coupled data assimilation, the competing and at times additive influence of the initialization and model errors can change the behavior of the air-sea interaction physics and upper ocean dynamics.

Ocean Model Metrics

Primary Author: McClean, Julie

Ocean Model Metrics

Julie McClean

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Our ability to simulate observed global-scale and regional warming trends over the past century and subsequently project planetary climate change largely depends on the veracity of the climate simulations produced by numerical models of the Earth system. The importance of simulating the ocean as accurately as possible in climate studies results from its role in storing and transporting heat, energy, freshwater, nutrients, and dissolved gases such as CO₂. The ocean acts as a heat capacitor in the coupled atmosphere-ocean system and hence acts as an integrator of climate variability, introducing long time scales and slowing the rate of response to climate change forcing. Variability intrinsic to the ocean interacts with the atmosphere over a range of time scales to produce coupled modes of climate variability such as the El Niño–Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), and the Southern Annular Mode (SAM).

In this overview presentation, the fidelity of the ocean components of current generation fully coupled climate models will be discussed, particularly with respect to their ability to represent ENSO. The depiction of the mean and variability of the general circulation by fine spatial resolution stand-alone ocean models that are to be used for short-term forecasting and/or eventually climate projections in fully coupled systems will be examined. Quantities calculated from data with near-global coverage and high temporal resolution such as sea surface height from altimetry and velocities from surface drifting buoys provide base-line assessments of model performance. A suite of progressively higher resolution simulations of the Southern Ocean will be used to demonstrate the importance of fine spatial resolution when modeling the meridional overturning circulation.

Mean Climate States and Their Resolution Dependences in a 20-km-mesh Global Atmospheric Climate Simulations

Primary Author: Mizuta, Ryo

Additional Authors: Kazuyoshi OOUCHI, Hiromasa YOSHIMURA, Shoji KUSUNOKI, and Akira NODA

Mean Climate States and Their Resolution Dependences
in a 20-km-mesh Global Atmospheric Climate Simulations

Ryo MIZUTA (1,2), Kazuyoshi OOUCHI (1,2)
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A global atmospheric general circulation model with the horizontal grid size of about 20 km has been developed, making use of the Earth Simulator, one of the fastest computers available for meteorological applications. We examine the model's performance of simulating the present day climate from small scale through global scale by time integrations of over 20 years using a climatological sea surface temperature as a boundary condition.

Global distributions of the seasonal mean precipitation, surface air temperature, geopotential height, zonal-mean wind and zonal-mean temperature agree well with the observations. By increasing horizontal resolution, the model improves the representation of regional-scale phenomena, such as tropical cyclones and Baiu fronts, and that of local climate and extreme events, due to better representation of topographical effects and physical processes.

Although most characteristics of global climate do not depend on resolution, the amount of precipitation in the tropics increases, corresponding to a warm bias in the tropical upper troposphere. The increase is seen in precipitation from grid-scale condensation, but it is not balanced with the decrease of precipitation from convective parameterization scheme. Dependence on horizontal resolution is also seen in a meridional contrast of specific humidity between tropical upper troposphere and polar lower stratosphere. Difference in water vapor transport by synoptic disturbances can cause the resolution dependence.

Error Characteristics Caused by Radiation of Global NWP Model

Primary Author: Murai, Shigeki

Error Characteristics Caused by Radiation of Global NWP Model

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It is well known that NWP models have much uncertainty in their schemes related to cloud-radiation interaction. To know this uncertainty, influence on forecast performance by changing parameters of a radiation scheme is studied using a global atmospheric model of Japan Meteorological Agency (JMA), as a part of the RR2002 project funded by MEXT.

In order to save a calculation cost, our model calculates longwave radiation every 3 hours and shortwave hourly. On the other hand, cloud cover and water content are prognostically determined by the cloud scheme and are used in radiation calculations. This may lead to inconsistency between clouds given for the radiation scheme and those predicted in the cloud scheme. Influence of the inconsistency was investigated on radiation flux, cloud field and air temperature. The impacts on their diurnal cycle were also evaluated.

Our model has specific errors in radiation fields at the surface and the top of atmosphere. The errors may partly come from inadequate treatment of clouds in the radiation calculations. Cloud overlap assumption is one of important parameters to simulate cloud radiative forcing in a model. The relevance of some overlap assumptions are evaluated for models with various spatial resolution focusing on the radiation flux at the surface and TOA.

The Effects of Solar Radiation on the Daily Mean Heat Flux in Canopy Model

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Diurnal Variation of Rain and Cloudiness

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Prediction of diurnal variation of rain and cloudiness by GCMs is not well correspond to that of observation. These errors may produce the errors of solar radiation budget, which potentially influence long time energy budget. In this study, we did numerical experiment in order to examine the influence of diurnal variation of shortwave radiation on the energy flux from land and vegetation. We use the multilayer canopy model !HMINCER!! (Watanabe et. al., 2006). The model is driven with two atmospheric data set: one is the averaged three typical sunny days in August 1987 at the middle of Japan (case 1), and the other is the average of the data in case 1 (case 2). In the case 1, the variables in the data set have a diurnal variation, whereas they are constant in time in case 2. The integrated shortwave radiation in two cases is the same. The integration time in both cases is 7 days.

In case 1, the 7-days averaged sensible heat flux is larger than that in case 2. The increase of turbulent viscosity in case 1 owing to the imbalance in daytime causes large sensible heat flux. As a result, the total energy flux from the canopy top in case 1 is 5 to 6 W m⁻² larger than that in case 2. Considering that the radiation forcing by CO₂ is estimated as only 1 to 2 W m⁻², our result suggests that the diurnal variation of solar radiation may produce the remarkable error of energy flux from canopy model.

The Role of Convective Moisture Sensitivity in Improving Major Systematic Biases in the Community Climate System Model (CCSM)

Primary Author: Neale, Rich

The Role of Convective Moisture Sensitivity in Improving Major Systematic Biases in the Community Climate System Model (CCSM)

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The NCAR Community Climate System Model (CCSM3) exhibits persistent systematic errors in three important atmospheric phenomena: an excessive diurnal cycle amplitude over land, weak MJO-type variability at the wrong frequency and a strong ENSO with a fast 2-year period. All these phenomenon involve an intimate coupling relationship with convection and, therefore, the presence or absence of free tropospheric humidity.

Changing the existing undilute convective plume calculation to a dilute calculation to determine the height and strength of convection increases the sensitivity to tropospheric humidity and reduces the sensitivity to the surface. The change has a significant impact in dramatically improving these systematic errors. This talk will investigate how these key phenomena operate differently with the enhanced sensitivity to moisture provided by the scheme changes. We will also show that an association between improvements in MJO activity and the frequency of ENSO may involve significant scale interaction.

Simulation of Tropical Variability in HiGEM

Primary Author: Norton, Warwick

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Simulation of Tropical Variability in HiGEM

Warwick Norton, Len Shaffrey, Pete Innes, Kevin Hodges(1), James Harle(2)

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HiGEM is a new high resolution climate model based on the Hadley Centre HadGEM model where the resolution has been increased to 1 degree in the atmosphere and 1/3 degrees in the ocean. Comparison with the equivalent HadGEM model (1.5 degree atmosphere and 1 degree ocean) is examined to assess the impact of increased resolution on tropical variability including the representation of tropical weather systems, cyclones and the simulation of the MJO. HiGEM reproduces the local-air sea coupling associated with tropical instability waves as observed by QuikSCAT. Implications this could have for the mean state of the tropical East Pacific are discussed.

Turbulence Collision Enhancement in Convective Clouds

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Turbulence Collision Enhancement in Convective Clouds

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There is a growing consensus that the collision growth rate of cloud droplets can be increased by turbulence. We have performed numerical simulations of convective clouds to investigate the turbulence effects on cloud droplet collisions. We used the collision kernel model which we had developed to predict the collision frequency in cloud turbulence. Preliminary results of our simulations have shown that the particle collision growth is dramatically promoted by turbulence in orographic convective clouds. They have also shown that the total amount of rainfall over a mountain is significantly increased. These results indicate that we have to take the turbulence enhancement into account in mesoscale weather simulations.

Systematic Errors in the IPCC AR4 Model Simulations of Atmospheric and Terrestrial Components of the Arctic Ocean Freshwater Budget

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Systematic Errors in the IPCC AR4 Model Simulations of Atmospheric and Terrestrial Components of the Arctic Ocean Freshwater Budget

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IPCC AR4 ensemble simulations of atmospheric and terrestrial components of the Arctic Ocean freshwater budget are considered. Precipitation and its difference with evapotranspiration over the Arctic Ocean and its terrestrial watersheds, including the basins of the four major rivers draining into the Arctic Ocean: the Ob, the Yenisey, the Lena, and the Mackenzie, are main foci of the analysis. Compared to the previous (IPCC TAR) generation of AOGCMs, there are some indications that the models as a class have improved in simulations of the arctic precipitation. In spite of observational uncertainties, the models still appear to oversimulate area-averaged precipitation over the major river basins. The model-mean precipitation biases in the Arctic and sub-Arctic have retained their major geographical patterns, which are at least partly attributable to the insufficiently resolved local orography, as well as to biases in large scale atmospheric circulation and sea-ice distribution. The river discharge into the Arctic Ocean is also slightly oversimulated. The simulated annual cycle of precipitation over the Arctic Ocean is in qualitative agreement between the models as well as with observational and reanalysis data. This is also generally the case for the seasonality of precipitation over the Arctic Ocean's terrestrial watersheds, with a few exceptions. Some agreement is demonstrated by the models in reproducing positive 20th century trends of precipitation in the Arctic, as well as positive area-averaged P-E late-20th century trends over the entire terrestrial watershed of the Arctic Ocean.

Three-Dimensional Tropospheric Water Vapor in Coupled Climate Models Compared with Observations from the AIRS Satellite System

Primary Author: Pierce, David

Additional Authors: Tim P. Barnett, Eric J. Fetzer, Peter J. Gleckler

Three-Dimensional Tropospheric Water Vapor in Coupled Climate Models Compared with Observations from the AIRS Satellite System

David W. Pierce, Tim P. Barnett, Eric J. Fetzer, Peter J. Gleckler

Changes in the distribution of water vapor in response to anthropogenic forcing will be a major factor determining the warming the Earth experiences over the next century, so it is important to validate climate models' distribution of water vapor. In this work the three dimensional distribution of specific humidity in state-of-the-art climate models is compared to measurements from the AIRS satellite system. We find the majority of models have a pattern of drier than observed conditions (by 10-25%) in the tropics below 800 hPa, but 25-100% too moist conditions between 300 and 600 hPa, especially in the extra-tropics. Analysis of the accuracy and sampling biases of the AIRS measurements suggests that these differences are due to systematic model errors, which might affect the model-estimated range of climate warming anticipated over the next century.

Trends in Short-wave and Long-wave Radiation in Models Compared to Satellite Observations

Primary Author: Penner, Joyce

Additional Authors: Natalia Andronova, and Li Xu

Trends in Short-wave and Long-wave Radiation in Models Compared to Satellite Observations

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We examine the 15 years of satellite data, from 1984 to 1999, from the ERBE instruments on the ERBS satellite in comparison to 20 different GCMs. ERBE longwave fluxes increase during this period while shortwave fluxes decrease. The modeled longwave flux trend is close to zero during this time period, while the modeled shortwave flux trend is significantly smaller than the observed trend. We also use a trajectory mapping to examine the short term trends after Pinatubo, together with an intercomparison of modeled and observed temperatures. We find considerable discrepancies between observations and all AR4 model simulations in reproducing the post-Pinatubo longwave and shortwave signals. We discuss the possible reasons for these discrepancies.

The Role of SCMs and CRMs for Investigating Biases in NWP and Climate Models

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The Role of SCMs and CRMs for Investigating Biases in NWP and Climate Models

Jon Petch, Steve Derbyshire, Anna Maidens, Martin Willett and Ricky Wong

Single column versions of climate and NWP models (SCMs) are a powerful tool for investigating the behaviour of the physical parametrizations in large scale models. This is because they use very little computer time and allow the parametrizations to be tested in isolation of the large scale dynamics. They also provide a good method for a direct comparison with a cloud-resolving model (CRM). However, through isolating the parametrization from the dynamics, an SCM is unlikely to show all the biases seen in the full model and may well have different biases of its own. It is therefore important to understand when an SCM is, and is not, an appropriate tool for better understanding a particular model bias.

In this presentation I will show results from the latest GCSS deep WG case study where a single column from a full NWP simulation is compared with SCM and CRM simulations of observed convective systems. I will also present results from idealised SCM and CRM experiments. In each case I will discuss how the behaviour of the SCM can be linked to understanding biases in the full model and also where the SCM behaviour is a red herring and not linked to biases seen in the full model.

Using ARM Observations to Evaluate Continental Surface Processes in Atmospheric Climate Models

Primary Author: Phillips, Thomas

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Using ARM Observations to Evaluate Continental Surface Processes in Atmospheric Climate Models

Thomas Phillips and CAPT Project Participants

Improving the sub-gridscale parameterizations in global climate models is key to enhancing their simulations of the historical climate and, by implication, their projections of future climate change. Deficiencies in the parameterizations of an atmospheric global climate model (AGCM) at short timescales can be inferred by:

- 1) initializing the AGCM's state variables realistically from a global weather analysis that is mapped to the model's horizontal and vertical grids,
- 2) operating the AGCM as a coarse-resolution weather-forecast model, and
- 3) applying high-frequency observations to identify systematic errors in forecast variables that are strongly impacted by the parameterizations.

Analysis of the systematic forecast errors then can guide efforts to make more realistic the AGCM's parameterized processes. In the experience of the NWP centers, the resulting reduction of forecast errors often correlates with enhanced model performance at climate timescales as well.

The U.S. Department of Energy's 'CAPT' project is applying this NWP-inspired methodology to identify systematic errors in forecasts made with two climate AGCMs--the NCAR CAM3 and the GFDL AM2 models. Central to this investigation are high-frequency field observations supplied by the USDOE's Atmospheric Radiation Measurement (ARM) program at sites representative of diverse climatic regimes (e.g. tropical Pacific, continental U.S., and Arctic climates). Especially noteworthy are hourly atmospheric observations for the entire year 2000 recorded at the ARM site on the U.S. Southern Great Plains (SGP). Once a GCM's forecast variables have been interpolated to the SGP observational grid, it thus is feasible to closely evaluate parameterization-dependent processes over a wide range of continental synoptic conditions.

The present study focuses on systematic errors in year 2000 model forecasts of surface processes at the SGP site. Variables of particular interest include surface radiative fluxes and precipitation, as well as model responses to these forcings in the form of surface turbulent fluxes, temperatures, and humidities. For each season, statistical metrics are used to identify model systematic bias and phase errors in the entire collection of hourly samples of a forecast variable, as well as in its daily averages and mean diurnal cycle. The systematic errors are found to vary substantially according to process, season, and model. In the summer season, for example, SGP precipitation in CAM3 occurs too frequently, due to an overactive convective scheme, while it is too sparse in AM2, possibly because the observed propagation of convective systems across the SGP region is inadequately captured. Other instances of systematic errors that illustrate potential parameterization deficiencies in these AGCMs also will be discussed.

Evaluating Climate Model Simulations of Clouds, Radiation, and Precipitation

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Evaluating Climate Model Simulations of Clouds, Radiation, and Precipitation

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Global climate models are the main tool used to project future climate, and many such models exist, both among the various modeling centers and over time, as each model is developed. Predictions of future climate change are not(yet) verifiable, so model skill must be evaluated by comparing simulations of present-day climate with observations. But how is this comparison to be made? The climate modeling community has no agreed-upon measures of skill, so models are evaluated with a constantly-changing set of criteria. Furthermore, climate models are often assessed by examining both forced modes (i.e. the annual, seasonal, or diurnal cycles) and modes that represent internal variability (i.e. El Nino or the Madden-Julian oscillation). By contrast, the weather forecasting community has a common, well-defined set of metrics for forecasts. Metrics are low-order measures of skill; they indicate model performance (and may not help isolate the root of any model flaws). The metrics useful for short term forecasts, however, are very useful for climate simulations.

In this talk I'll present a short hierarchy of metrics for evaluating the simulation of clouds, radiation, and precipitation in the present-day climate. There are three inter-related components: 1) the choice of which variables to examine; 2) the choice of which observations to use; and 3) the choice of which statistics are to be computed. The metrics are simple to compute from low-resolution data(i.e. monthly mean fields of single-level quantities) so models (or versions of models) may be easily compared. I'll show the metrics for all runs submitted to the IPCC database for the Fourth Assessment as well as two potential ringers, and demonstrate an extension to the diagrams developed by Karl Taylor to summarize three statistical quantities for each model at one time.

Identifying Climate Model Deficiencies in Simulating Tropical Intraseasonal Variability: Application of Weather-Forecasting and Single-Column-Modeling Methodologies

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Identifying Climate Model Deficiencies in Simulating Tropical Intraseasonal Variability: Application of Weather-Forecasting and Single-Column-Modeling Methodologies

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Today's climate models have difficulty accurately simulating intraseasonal variability in the tropical atmosphere. For example, the simulated amplitude of the 30-60-day Madden-Julian Oscillation (MJO) is too weak, and its propagation speed too rapid errors which may result from deficiencies in model physics (e.g. its cumulus parameterization), resolution, mean state, or air-sea coupling. In climate simulations, it is difficult to identify the primary model deficiencies responsible for such shortcomings, since their effects tend to be masked by nonlinear interactions of multiple processes and the resulting compensation of errors.

To address this issue, the USDOE-sponsored project known as CAPT (Climate Change Prediction Program-Atmospheric Radiation Measurement Program Parameterization Testbed) has developed a protocol for running a climate model in weather-forecast mode. We identify incipient model errors (i.e. those developing prior to significant process interaction) by comparing the short-range forecasts of atmospheric variables with high frequency verification data provided by reanalyses, satellites, and field campaigns such as the Tropical Ocean Global Atmosphere Coupled Ocean-Atmosphere Response Experiment (TOGA-COARE). Analyzing these forecast errors may permit more direct identification of model deficiencies. In this study, we analyze the simulated tropical intraseasonal variability of two U.S. AGCMs: version 3 of the NCAR Community Atmosphere Model (CAM3) and version 2 of the GFDL Atmospheric Model (AM2). After daily initialization of the models with realistic global state variables approximated by the ERA-40 reanalyses during the TOGA-COARE Intensive Observing Period (1 November 1992 to 28 February 1993), we generate a series of short-range weather forecasts, and verify these against available observational data. To assist our analysis of the CAM3, we also employ its single column model which we force with the analysis of TOGA-COARE data. We will present results of our forecast-error analysis for CAM3 and AM2, discussing potential parameterization deficiencies in each model. We also will compare these results to the intraseasonal variability of the models when run in climate mode and for the CAM3 we will contrast the results obtained with alternate parameterizations of convection

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Errors in Tracer Transport, and Convergence to the Exact Answer

Primary Author: Prather, Michael

Errors in Tracer Transport, and Convergence to the Exact Answer

Michael Prather, UC Irvine

The use of tracer transport models in inverse problems or isotopic studies requires a level of accuracy that many current models likely do not meet. Most numerical methods for tracer transport have only been tested under idealized flows and not under realistic 4-D convergent/divergent flows for which no analytic solution exists. This work presents a comparison of two different methods under the same flow field: an annual cycle of 3-hour winds from the GISS stratosphere-troposphere general circulation model. The relatively large difference between the two methods is a measure of the transport error in one or both of the methods. The convergence of both methods as the grid size is successively halved shows a geometric convergence as expected and further allows one to estimate the errors in each schemes as well as demonstrate that both are or are not solving the same problem. Given the magnitude of the error of the original solution on the native grid, it is likely that transport of scalars is still a notable source of error in climate and NWP models.

The Mean Climate of the IPCC AR4 Models: Individual, Systematic, and Ensemble Mean Errors

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The Mean Climate of the IPCC AR4 Models:
Individual, Systematic, and Ensemble Mean Errors

Thomas Reichler and Junsu Kim
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Climate models do not consistently and correctly simulate climate. In fact, differences among models are often larger than the projected change itself. This calls into question model based predictions of future climate change. It also highlights the need for a systematic study of model performance aimed at better understanding the strength and weaknesses of current models.

We present a new index of model performance, which measures the ability of models to simulate various aspects of the present-day mean climate. The index is composed of the aggregated and normalized errors in simulating 35 observation based fields taken from the atmosphere, ocean, and land surface.

The index is used to discuss the performance of the latest IPCC AR4 models on the global domain. We compare individual models with each other, we examine systematic model errors, and we investigate the role of external forcings and specific model features for the quality of the simulations. It is shown that by combining the simulations of many models a climate which is far superior to that of each individual model is realized. Reasons and consequences for this interesting behavior are discussed.

Systematic Errors in the NWP System of DWD: Detection, Diagnosis and Recent Progress

Primary Author: Ritter, Bodo

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Systematic Errors in the NWP System of DWD: Detection, Diagnosis and Recent Progress

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The NWP system of the Deutscher Wetterdienst (DWD) is focusing on short range weather forecasting with particular emphasis on the hydrological cycle and the prediction of severe weather events. The operational system comprises a global forecast model based on an icosahedral grid structure and a non-hydrostatic limited area model with a rotated latitude-longitude grid centered over Europe. In addition, a very high resolution limited area model covering Germany and the surrounding region, resolving deep convection explicitly, is currently undergoing pre-operational testing and will serve in the future as a very short range forecast model both in a deterministic frequent update mode and as core component of a limited area ensemble system.

Evaluation of all components of the system as a continuous monitoring and validation task provides insight in existing model deficiencies, their origins and potential improvements. One objective of this presentation will be the illustration of the usefulness of intermodel comparative monitoring in the diagnosis of model shortcomings and their relation to specific aspects of the model formulation. For the global model of DWD it will be demonstrated how the continuous comparison of model products with other forecast centres facilitates the detection of problems which originate from shortcomings in the formulation of the models multi-layer soil model. Another subject, which will be discussed in the context of the limited area model of DWD, addresses the relation between systematic positional errors in the precipitation pattern and the choice of prognostic model variables. It will be illustrated, that at a model resolution typical for state-of-the-art limited area models, it is mandatory to include snow and rain as additional prognostic quantities in order to avoid severe systematic errors in the distribution of surface precipitation. Some preliminary results from the pre-operational testing of the very high resolution model test suite will be shown to demonstrate the potential benefits to the forecast quality which may be expected in the near future, when limited area models are able to provide operational forecasts at a horizontal resolution of only a few kilometers. However, it will also be shown, that even at such a resolution, uncertainties in the parametrisation modules employed, e.g. the cloud microphysics scheme, still have a large impact on important forecast products.

Relationships Between Model Tropical Oceanic Precipitation Biases and Surface Energy Fluxes

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Relationships Between
Model Tropical Oceanic Precipitation Biases and Surface Energy Fluxes

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Despite continued improvements in physical parameterizations in climate models, feedback processes involving radiative fluxes and turbulent energy exchange between the surface and atmosphere remain weak links in coupled climate modeling. Because precipitation structure and its variability, particularly over the tropical oceans, is an end result of these energy exchanges, it too has been a persistent trouble spot for "AMIP-like" simulations (i.e. specified SST) and coupled models alike. The propensity for "double ITCZ" configurations over the Pacific and poor rainfall simulations over the Indian Ocean and Asian Monsoon region are typical examples. In this work we use output from AR4 AMIP and coupled model integrations, along with experiments with the new NASA Global Modeling and Assimilation Office GEOS-5 AGCM to study relationships between poor precipitation simulations and the behavior of energy fluxes at the surface and at TOA.

In particular, we consider the role of latent heat flux and SW cloud forcing in controlling SST gradients and examine modes by which associated moist static energy transports link these flux processes and precipitation. C20C and AMIP integrations are the primary data sets used to characterize systematic differences in these relationships. One possibility for explaining poor precipitation structure in AMIP integrations is that an exaggerated wind-evaporation feedback develops when the link between AGCM fluxes and SST evolution is disabled. Several experiments using the NASA GEOS-5 model are also used. In one experiment type observed surface wind speeds from reanalyses are used in the model bulk aerodynamic formula to ensure a more direct link between SST and fluxes. A second experiment type involves initializing the model from an assimilation cycle, but then integrating in "climate mode" and examining the evolution of systematic biases over several days as the model drifts toward its climatology. These model diagnostics are supplemented with statistics of radiative and turbulent flux relationships derived largely from global satellite measurements (e.g. ISCCP-FD radiation, HOAPS latent heat flux, GPCP precipitation).

Using NWP to Assess Climate Models

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Using NWP to Assess Climate Models

M. Rodwell and T. N. Palmer

Estimates of climate change remain uncertain - hampering strategic decision making in many sectors. In large part this uncertainty arises from uncertainty in the computational representation of known physical processes. This model component of climate change uncertainty is increasingly being assessed using perturbed model experiments. Some such model perturbations have, for example, led to headline global warming estimates of as much as 11K. These experiments consider many differently perturbed versions of a given base model and assess the likelihood of each perturbed model's climate prediction based on how well it simulates present-day climate. In these experiments, the computational cost of the model assessment is extremely high unless one assumes that the climate anomalies associated with different model perturbations can be combined linearly. Here we demonstrate a different method that harnesses the power of the data assimilation system to directly assess the perturbed physics of a model. Data assimilation involves the incorporation of daily observations to produce initial conditions (analyses) for numerical weather prediction(NWP). The method used here quantifies systematic initial tendencies in the first few timesteps of a model forecast. After suitable temporal meaning, these initial tendencies imply imbalances in the physical processes associated with model error. We show how these tendencies can be used to produce probability weightings for each model that could be used in the construction of p.d.f.s of climate change. The approach typically costs 5% of the cost of a 100-year coupled model simulation that might otherwise be used to assess the simulation of present-day climate. Importantly, since the approach is amenable to linear analysis, it could further reduce the cost of model assessment by several orders of magnitude: making the exercise computationally feasible. The initial tendency approach is only able to assess "fast physics" perturbations, i.e. perturbations that have an impact on weather forecasts as well as climate. Recent publications suggest that the majority of present model parameter uncertainty is associated with fast physics. If such a test were adopted, the assessment of the ability of a model to simulate present-day climate would only be required for models that "pass" the fast physics test. The study highlights the advantages of a more seamless approach to forecasting that combines numerical weather prediction, climate forecasting and all scales in-between.

Turbulent Fluxes at the Surface of the Ocean from Models and Observations

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Turbulent Fluxes at the Surface of the Ocean from Models and Observations

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Latent heat flux is an important term in the heat and energy balance and the water cycle over the ocean. In this study we are evaluating IPCC models using observational (buoy and ship measurements) and satellite derived fluxes from several platforms. Significant biases are found in all models in particular over the warm pool region in the Indo-Pacific Oceans.

Sensitivity of Arctic Subsurface Hydroclimate to Physical Terrestrial Representation in Global Climate Model

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Sensitivity of Arctic Subsurface Hydroclimate to Physical Terrestrial Representation in Global Climate Model

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The land cryosphere, mostly underlain by permanently or seasonally frozen ground, may experience large changes under global warming, which can exert a large impact on the socio-economy and the eco-climate system in the local areas, as well as remote influences on climate in other regions. Physiochemical (e.g. albedo, freshwater discharge to the Arctic) and/or biological (e.g. anaerobic decomposition of tundra) feedbacks and interactions are probable linkages. Identification of sources of systematic errors in the current physical (thermal and hydrological) terrestrial schemes, and attempt to eliminate those sources, constitute a foundation for further investigations of the above-mentioned issues.

Reproducibility of the subsurface thermal regime by a global climate model (CCSR/NIES/FRCGC CGCM) is critically examined based on its outputs for IPCC AR4. Sensitivity of subsurface hydro-thermal regimes to changes in specifications at physical terrestrial scheme (MATSIRO) used for the IPCC AR4 integration was investigated to identify the sources of systematic errors. Examined are the prescribed soil and snow properties (e.g. thermal conductivity and heat capacity), thermal parameterization, resolved depth and thickness of soil layers, and initial conditions. The results indicate that assignment of appropriate value to physical properties is as important as improvement of parameterization and soil column settings.

Resolved and Parameterized Waves in Climate Models

Primary Author: Scinocca, John

The impact of waves, both resolved and parameterized, on the general circulation of the atmosphere is essential to credibly model the climate system. The importance of parameterized orographic gravity-wave drag (GWD) to the tropospheric winds, temperatures, and mass distribution is now well appreciated. The upward extension of atmospheric general circulation models (GCMs) into the stratosphere and mesosphere requires the additional parameterization of non-orographic GWD. Even so, orographic GWD appears to play a pivotal role in modelling stratospheric wind and temperature distributions that support chemical climate modelling.

Resolved tropical waves in GCMs are essential to the intraseasonal oscillation of the troposphere and the quasi biennial and semi-annual oscillations of the stratosphere and mesosphere. Observations suggest that these waves are primarily forced by deep latent heating associated with tropical deep convection. In GCMs, however, recent analysis has revealed that tropical deep latent heating arises from a competition between parameterized deep convection and spurious behaviour of the resolved stratiform precipitation. Depending on the parameters employed for the deep convection, this artificial behaviour of the stratiform precipitation can dominate the mean and variance of tropical deep latent heating and so provide the primary source of resolved waves.

This spurious behaviour of the stratiform precipitation was first identified in the mesoscale modelling community where it was found to be associated with the phenomenon of grid-point storms. In similar fashion such grid-point vortices of intense precipitation are found in GCM simulations when the stratiform precipitation dominates the tropical deep latent heating. In addition to wave phenomena, it is demonstrated that modelled ENSO and analyses of extreme precipitation events are highly sensitive to this problem.

Evaluation of the NCEP CFS Tier-2 Experiment with Bias Corrected SST Forecast

Primary Author: Schemm, Jae-Kyung

Evaluation of the NCEP CFS Tier-2 Experiment with Bias Corrected SST Forecast

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As a transition project of NOAA Climate Test Bed, series of experimental forecast runs were made with the atmospheric component of the NCEP CFS GCM and bias corrected SST forecast from the coupled CFS hindcast runs. The primary objective is to assess the impact of improved SST forecast on seasonal climate prediction. The hindcast sets include 6-month forecast runs with initial conditions in the month of January, April, July and October for the 1981-2004 period. Comparisons will be made on the model systematic error of the coupled and tier-2 runs. Assessment on the impact of the SST bias correction will be presented in terms of the changes in atmospheric mean state and interannual variability. Also evaluated will be the extent of influence of ocean-atmosphere interaction on the atmospheric variability.

Recent Efforts to Alleviate Tropical Biases

Primary Author: Schneider, Edwin

Recent Efforts to Alleviate Tropical Biases

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A recent ongoing organized effort to alleviate tropical biases in coupled GCMs, involving scientists from several institutions, is described. The bias that has received the most attention is the split-ITCZ problem in the tropical Pacific, although biases in the annual cycle of SST in the equatorial Pacific and ENSO variability are also of great interest. An overview of this effort is presented, including causal hypotheses that have been put forward and sensitivity tests that have been performed. Two competing hypotheses that will be explored are: one that the cause of the biases is due to errors in parameterizations in the atmospheric model, and the other that the causes are rooted in the ocean model. The problem of how to organize community efforts to accelerate progress in alleviating the biases will be addressed.

Assessing Climate Change Risks Using a Multi-Model Approach: Equal Weighting Versus Weighting by Performance

Primary Author: Scholze, Marko

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Assessing Climate Change Risks Using a Multi-Model Approach: Equal Weighting Versus Weighting by Performance

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We quantify the risks of climate-induced changes in key ecosystem processes during the 21st century by forcing a dynamic global vegetation model with multiple scenarios from the IPCC AR4 data archive using 16 climate models and mapping the proportions of model runs showing exceedance of natural variability in wildfire frequency and freshwater supply or shifts in vegetation cover. Our analysis does not assign probabilities to scenarios. Instead, we consider the distribution of outcomes within three sets of model runs grouped according to the amount of global warming they simulate: $<2^{\circ}\text{C}$ (including committed climate change simulations), $2\text{--}3^{\circ}\text{C}$, and $>3^{\circ}\text{C}$. Here, we are contrasting two different methods for calculating the risks: first we use an equal weighting approach giving every model within one of the three sets the same weight, and second, we weight the models according to their ability to model ENSO. The differences are underpinning the need for the development of more robust performance metrics for global climate models.

Observational Constraints on Probabilistic Predictions Based on Imperfect Climate Models

Primary Author: Sexton, David

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Observational Constraints on Probabilistic Predictions Based on Imperfect Climate Models

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Murphy et al (Nature 2004) introduced the perturbed physics ensemble where each member is generated by altering the values of several uncertain input parameters in the slab version of a standard climate model, HadSM3. They used the ensemble to provide a probabilistic prediction of climate sensitivity which accounted for parametric modelling uncertainty. An important aspect of the analysis was how different parts of parameter space were weighted according to their ability to simulate present-day climate.

Since then, the method for generating probabilistic predictions has been improved by adopting a similar but more rigorous Bayesian methodology developed by statisticians in the field of Computer Experiments. We describe the way in which the Bayesian approach deals with observations used to constrain the probabilistic predictions. It allows us to use lots of different observations to weight parts of parameter space according to model quality and we explain why we favour this multivariate approach. The Bayesian framework introduces a new term into the weighting function, called discrepancy, which quantifies the degree of imperfection in the model's representation of the real climate system. Given the size of systematic errors in the current generation of climate models, this term has important consequences for what we can say about the future climate.

We use the AR4 multimodel ensemble to provide a 'proxy' estimate of the magnitude of the discrepancy term and show what affect it has on our probabilistic predictions. Therefore this is an early example of how perturbed physics ensembles and multimodel ensembles can be combined to provide a probabilistic prediction that accounts for both parametric and structural uncertainty.

Systematic Errors and SST Biases in HiGEM

Primary Author: Shaffrey, Len

Additional Authors: Ian Stevens, Amna Jrrar, and James Harle

Systematic Errors and SST Biases in HiGEM

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HiGEM is a national UK programme in high resolution coupled climate modelling. The new Hadley Centre coupled climate model HadGEM1 has been increased in resolution to 1 degree in the atmosphere and 1/3 degrees in the ocean. The aim is to advance the fidelity of simulations of the global environment, and to improve our understanding of climate variability on timescales from days to centuries.

This study will focus on the systematic errors in HiGEM, and in particular the evolution of systematic SST, sea-ice and upper ocean temperature biases. The role of the oceanic vertical diffusion in determining systematic errors in HiGEM will also be discussed.

Evaluation of Model Potential Predictability and Predictive Skill for Terrestrial Hydrology in a Bayesian Framework

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Evaluation of Model Potential Predictability and Predictive Skill for Terrestrial Hydrology in a Bayesian Framework

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Understanding the role of the terrestrial hydrosphere biosphere in the climate system, especially in the coupling of land surface hydrologic to atmospheric processes over a range of spatial and temporal scales, is a key scientific challenge. A general and consistent framework must be developed that allows the evaluation of coupled, ensemble climate models that include single run climate simulations, off-line model simulations, models of remote sensing retrievals, observation-based teleconnections, and model-observation predictability studies that cross scales. To this end we have developed a Bayesian statistical framework, to assess the predictability of the global water and energy cycles and evaluate models not only in terms of idealized predictability but also in their skill in predicting climate variability, including feedbacks and teleconnections.

The implementation of the system requires the estimation of the joint distribution between a measure of the model's prediction (e.g. the ensemble mean) and observations (or the measure that the model predictions are being compared to). The joint distribution is estimated using Copulas that have the advantage that the joint distribution can be estimated from the marginal distributions and a measure of dependency between the variables. The predictability skill is represented by the conditional distribution function for the predictive state conditional on a model prediction. Given skillful climate model predictions, this conditional distribution will have less variability than the distribution of the climate variable prior to the model predictions.

In this paper we present some results focusing on the states and main fluxes of the terrestrial water and energy cycles and derived quantities such as drought indices and extreme values. Firstly we look at the idealized model predictability or self-reproducibility, within their own climate system, using the long-term climate simulations from the IPCC 20th century and control simulations. The analysis provides an upper limit of predictability as a function of boundary conditions (20C3m and AMIP data) and how this varies globally and the temporal and spatial scales of predictability, recognizing that predictive skill may only be attained as we move to coarser scales. Secondly we show examples of model ability to predict observed climate connectivity for well known ENSO patterns as well as lesser known connections that are more difficult to model. The probabilistic framework can account for the uncertainties in the observations, variability in the physical connection and internal model variability.

Discriminating Robust and Non-Robust Atmospheric Circulation Responses to Global Warming

Primary Author: Sigmond, Michael

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Discriminating Robust and Non-Robust Atmospheric Circulation Responses to Global Warming

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The robustness of the atmospheric circulation response to global warming in a set of atmospheric general circulation models (AGCMs) is investigated. The global-warmed climate is forced by a global pattern of warmed ocean surface temperatures that is extracted from coupled ocean atmosphere climate model greenhouse warming simulations. The response of two independently developed AGCMs is compared, and then the dependence of the response on horizontal resolution and on a single tuning parameter, related to orographic gravity wave drag, is determined. Across these levels of comparison, the tropical and subtropical response is generally robust in zonal wind and temperature, but the extratropical response is non-robust. On regional scales, almost every aspect of the response appears to be non-robust, even to the simple variation of the gravity-wave drag parameter. Some evidence that the non-robustness of the simulated response to global warming might be predicted from the (non global-warmed) control simulation is presented: in particular, those parts of the response that are non-robust to a parameter variation tend to behave in a non-linear fashion under a similar variation in the control run.

Systematic Errors in the Tropics and the Role of Multi-Scale Interactions

Primary Author: Slingo, Julia

Systematic Errors in the Tropics and the Role of Multi-Scale Interactions

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Convection constitutes the fundamental building block of tropical weather systems and contains organization on a wide variety of space and time scales. It is now generally recognized that our very limited capability to simulate this multi-scale nature of organized convection lies at the root of many model systematic errors, both in numerical weather prediction and in coupled ocean atmosphere simulations of climate variability and change.

This paper will introduce the multi-scale nature of the tropical climate system and provide examples of current shortcomings in models; it will address how these shortcomings may contribute to systematic errors in simulations of the mean climate and its variability on timescales of days to years. Despite considerable improvements in model resolution and physics over the last decade, progress in solving these problems has been limited. This paper will present some new ideas for tackling multi-scale interactions, based on modelling and observational studies.

Relating the Diversity in Our Models to the Uncertainty in Our Future

Primary Author: Smith, Leonard

Relating the Diversity in Our Models to the Uncertainty in Our Future

Leonard A Smith

Today's state-of-the-art climate models consist of complicated computer simulation models of the Earth's climate system. In some respects, the simulations produced using these models bear a striking similarity to the observed climate system; in other respects, simulations produced by various state-of-the-art models differ significantly both from one another and the target system. How then does diversity in our models relate to uncertainty in our future? In particular, how might we interpret multi-model, multi-parameter, multi-initial condition model simulations under a given scenario, like doubling the level of CO₂ in the atmosphere? Current state-of-the-art models lend support, often quantitative, to the results derived from previous state-of-the-art models, results which now extend back for over a century. The aim of probability forecasts is considered within the hierarchy of model complexity suggested by past and future state-of-the-art models; this is considered in the context of long-term resource allocation following Thompson (1957). The importance of distinguishing strategic aims (model improvement) from tactical aims (policy and decision support), as well as the impact this distinction should have on the design of model experiments, is clarified. Such "climate-like" questions also arise in other areas of applied science, including oil exploration, the design of unstable nuclear devices, and the dynamics of influenza epidemics, and there too important questions remain concerning how to translate the output our models into support for our decision making.

The concept of Probabilist Similarity is introduced. Necessary conditions for making credible claims for (decision-relevant) probability forecasts are discussed, and it is argued that no decision-support-relevant probability forecast can be obtained today. The results of Bayesian analyses are considered explicitly. It is argued that the inconvenient truth we see in the observations of the recent past must be faced within an inconvenient ignorance of the future. (With this comes no suggestion that current models overstate the risks.) The additional risk that (literally) over-selling the current "best available information" holds for the credibility of science is noted, with examples. In order to see through our models, we must respect their limitations, even as these limitations decrease in the coming decades.

Modulation of the Diurnal Cycle of Rainfall by the Madden-Julian Oscillation in the CMIP3 GFDL CM2.1 Model

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Modulation of the Diurnal Cycle of Rainfall by the Madden-Julian Oscillation in the CMIP3 GFDL CM2.1 Model

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Recent satellite data indicates that the Madden-Julian Oscillation (MJO) modulates the diurnal cycle of deep convective cloud over the tropics (Tian et al. 2006). The amplitude of the diurnal cycle changes by approximately 50% over the eastern tropical Indian Ocean, and 20% over the western tropical Pacific Ocean, being larger (smaller) during the convective (non-convective) phase of the MJO. An analysis of 3-hourly rainfall from the CMIP3 GFDL CM2.1 climate of the 20th century simulation indicates that this model reproduces the observed modulation.

Coupled Model Simulations of Boreal Summer Intraseasonal (30-50 day) Variability: Validation and Caution on Use of Metrics

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Coupled Model Simulations of Boreal Summer Intraseasonal
(30-50 day) Variability: Validation and Caution on Use of Metrics

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Boreal summer intraseasonal (30-50 day) variability (BSISV) over the Asian monsoon region is more complex than its boreal winter counterpart, the Madden-Julian Oscillation (MJO), since it also exhibits northward and northwestward propagating convective components over India and the west Pacific. Here we analyze the BSISV in the CMIP3 and select CMIP2+ coupled ocean-atmosphere models. Difficulty remains in simulating the life-cycle of the BSISV, including the tilted rainband that is associated with the Rossby wave response to the eastward propagating equatorial convective anomalies (Annamalai and Sperber 2005). The ECHAM4/OPYC climate model, which is known to realistically represent the boreal winter MJO (Sperber et al. 2005), gives the most realistic simulation of the BSISV tilted rainband that is predicated on capturing the eastward equatorial propagation. This model also captures the initiation of the BSISV convection over the tropical western Indian Ocean that occurs in the presence of low-level easterly anomalies that are associated with the suppressed phase of the BSISV to the east, and the transition to low-level moisture convergence during the mature phase. The eastward propagation of convection and its relationship to sea-surface temperature, surface fluxes, and low-level moisture convergence is nearly identical to that of the boreal winter MJO. Northward propagation of convective anomalies are also preceded by low-level moisture convergence, though only in the vicinity of India. The extent of the northward propagation is related to the easterly wind shear (Lau and Peng 1990, Wang and Xie 1997, Annamalai and Sperber 2005). In the ECHAM4/OPYC model the simulated easterly shear does not extend as far north as observed, consistent with a dry bias in the monsoon rainfall climatology. The model also captures the interactive nature of the monsoon system including the link between the enhanced west Pacific rainfall and the onset of monsoon break over India.

Extreme caution is needed when using metrics, such as the pattern correlation, for assessing the fidelity of model performance, as models with the most physically realistic BSISV do not exhibit the highest pattern correlations with observations.

Analysis of the Errors in the Simulation of Indian Monsoon Rainfall in IPCC AR4 Simulations of the 20th Century Climate

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Analysis of the Errors in the Simulation of Indian Monsoon Rainfall in IPCC AR4 simulations of the 20th Century Climate

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The accurate simulation of monsoon rainfall by atmospheric General Circulation Models (GCM) and Coupled Ocean Atmosphere GCM have not been achieved so far. Hence it is necessary to understand the factors that lead to poor simulation of monsoon rainfall in GCM. We have used a simple diagnostic model to identify the sources of error in the simulation of Indian monsoon rainfall by IPCC AR4 simulation of the 20th century climate. We have examined the results from 12 coupled models in the IPCC archive along with simulations of the 12 AGCM that used observed SST as the boundary condition. A comparison of the results of coupled model along with that of AGCM helps in understanding how the ocean-atmosphere coupling influences the simulation of the monsoon. In 11 of the 12 coupled models, the Indian monsoon is weaker the coupled simulation when compared to the simulation by the AGCM that used observed SST. This is because in almost all the coupled models the SST is lower than observed. The diagnostic model relates the net radiation at the top of the atmosphere, integrated water vapor and vertical stability to monsoon rainfall. We show that in many GCM the relationship between rainfall and integrated water vapor is quite different from observations. For the same value of integrated water vapor, the models simulate higher rainfall than observations. Hence in simulation wherein SST is specified from observations (AMIP like simulations) the monsoon rainfall simulated by these models tends to be too high. When these AGCM are coupled to an OGCM they tend to produce realistic rainfall because the SST in the coupled model simulation is colder than the observations. The colder SST leads to a lower integrated water vapor over the Arabian sea. This leads to less advection of water vapor from ocean to land and hence reduces the monsoon rainfall in coupled simulations. Hence an accurate simulation of monsoon rainfall by coupled models could be on account of fortuitous cancellation of errors. In some GCM the atmosphere is vertically more unstable than observations. In such models, small increase in integrated water vapor leads to a large difference in the simulated monsoon rainfall. In the Africa, some of the models tend to produce high a rainfall in the Sahel region because the net radiation at the top of the atmosphere is much higher than observations.

Uncertainty and Confidence in Climate Forecasting

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Uncertainty and Confidence in Climate Forecasting

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Climate models are invaluable tools in research focused on understanding the processes of the climate system. They also represent powerful tools to provide information about changes in climate which might be expected as a result of increased atmospheric greenhouse gas concentrations. It is important however, to acknowledge the fundamental differences between weather forecasting and climate forecasting. In particular a weather forecasting system can be verified and improved by repeated tests in a way which is simply impossible for climate forecasts.

To maintain the long term credibility of climate science it is crucial to acknowledge the barriers to climate forecasts, whether they be one-off, "what if", scenarios or distributions of possibilities. We can thus examine the basis for claiming confidence in statements about future climate. At global scales constraints may be relatively simple and supported by basic physics. At regional scales the theoretical issues are much more complex.

The grand ensembles of climateprediction.net combine large initial condition ensembles and with large perturbed parameter ensembles and enable us to begin to examine the range and sources of uncertainty in climate predictions. Here we discuss five sources of uncertainty in climate forecasting and their implications for future experimental design. These uncertainties are illustrated with results from the climateprediction.net ensembles. The implications for observational strategies are discussed as well as methods of extracting robust and potentially valuable information on the 20 to 50 year timescale.

A Multi-Year Comparison of Lower Stratospheric Temperatures from CHAMP Radio Occultation Data with MSU/AMSU Records

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A Multi-Year Comparison of Lower Stratospheric Temperatures from CHAMP Radio Occultation Data with MSU/AMSU Records

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Long-term upper air temperature records have been established by different groups with considerable effort from radiosonde data and from satellite based (Advanced) Microwave Sounding Unit (MSU/AMSU) measurements, the latter providing information on layer-average stratospheric and tropospheric brightness temperatures. Comparisons of the temperature series show discrepancies not only with respect to radiosonde data but also between MSU data sets stemming from different retrievals. In this context the Global Navigation Satellite System radio occultation (RO) technique offers new possibilities by providing high quality observations of the atmosphere in an active limb sounding mode. Besides high accuracy and vertical resolution in the upper troposphere and lower stratosphere region one of the most important properties regarding climate studies is the long-term stability due to intrinsic self-calibration. Based on RO observations of the CHALLENGING Minisatellite Payload for geoscientific research (CHAMP) satellite since late 2001, CHAMP RO temperature climatologies have been constructed at the WegCenter/UniGraz. Focusing on the MSU lower stratosphere channel (TLS), synthetic TLS temperatures were calculated by applying global weighting functions to zonal-mean monthly-mean RO temperature climatology profiles for the years 2001–2006. These synthetic CHAMP TLS temperatures were compared to recent MSU TLS records from the University of Alabama in Huntsville (UAH, USA) and from Remote Sensing Systems (RSS, USA), as well as to synthetic TLS temperatures from HadAT2 radiosonde data (Hadley Centre/MetOffice, UK) and ECMWF (European Centre for Medium-Range Weather Forecasts) analyses. In terms of absolute temperature we found that CHAMP TLS temperatures globally agree better with UAH temperatures outside the summer season and with RSS within summer, while ECMWF temperatures generally agree better with RSS temperatures. In terms of TLS temperature anomalies, overall very good agreement of CHAMP temperature anomalies with UAH, RSS, and ECMWF anomalies was found for intra-annual variability (RMS difference < 0.1 K globally and in the tropics, < 0.2 K in the extratropics), whilst HadAT2 anomalies show significantly larger differences (factor of two globally and more in the extratropics) as well as a systematic cold offset of near –0.4 K. Regarding 2001–2006 trends, UAH, RSS, and ECMWF exhibit a statistically significant cooling trend difference to CHAMP in the tropics (~ –0.45 K/5yrs) and globally (~ –0.35 K/5yrs). In view of the global homogeneity and long-term stability of the RO data this indicates that the MSU/AMSU TLS temperature record overestimates the early 21st century cooling trend especially in the tropical upper troposphere/lower stratosphere region but also globally.

Lagrangian Transport of Water Vapor and Cloud Water in the ECHAM4 GCM and Its Impact on the Cold Bias

Primary Author: Stenke, Andrea

Additional Authors: Volker Grewe, Michael Ponater and Robert Sausen

Lagrangian Transport of Water Vapor and Cloud Water in the ECHAM4 GCM and Its Impact on the Cold Bias

Andrea Stenke, Volker Grewe, Michael Ponater and Robert Sausen

The Lagrangian advection scheme ATTILA has been applied for the transport of water vapor and cloud water in the general circulation model (GCM) ECHAM4.L39(DLR) (E39) instead of the operational semi-Lagrangian transport scheme (SLT). ATTILA is a purely Lagrangian scheme that is numerically non-diffusive and strictly mass conserving, while the operational semi-Lagrangian scheme exhibits a considerable numerical diffusion in the presence of sharp gradients. So far, ATTILA has been applied for the transport of passive tracers exclusively. The model version E39/SLT significantly overestimates the water vapor mixing ratio in the extratropical lowermost stratosphere by a factor of 3-5 compared to HALOE observations ('wet bias'). Compared to E39/SLT, E39/ATTILA shows substantially reduced water vapor mixing ratios in the extratropical lowermost stratosphere by about 70%, and a steeper meridional water vapor gradient in the subtropics which is in better agreement with observations. Furthermore, the temperature distribution as simulated with E39/SLT is characterized by a pronounced cold temperature bias in the extratropical lowermost stratosphere ('cold bias'), a problem which is present in many other atmospheric GCMs. Furthermore, E39/SLT shows a cold temperature bias in the polar stratosphere above 50 hPa in winter ('cold pole'). The improvements concerning the water vapor distribution in E39/ATTILA lead to a substantial reduction of the simulated cold bias by approximately 5-7 K, i.e. half of the cold bias in E39/SLT is caused by the wet bias in the lowermost stratosphere. Furthermore, the reduced temperature error results in a better representation of the modeled tropopause, especially in the extratropics. Sensitivity studies indicate that the warming of the extratropical lowermost stratosphere in E39/ATTILA is directly related to the reduced wet bias resulting in a less infrared cooling. Additionally, the cold pole problem is also slightly reduced in E39/ATTILA by approximately 2-5 K. The transport of water vapor and cloud water with the Lagrangian transport scheme ATTILA constitutes a major improvement compared to E39/SLT with respect to modeled water vapor and, as a consequence, modeled temperatures and dynamics.

New Emerging Global Data Sets for Examining Global-Scale Controls on Precipitation and Evaluating the Representation of Clouds and Precipitation in Weather and Climate Models

Primary Author: Stephens, Graeme

Additional Authors: Todd Ellis

New Emerging Global Data Sets for Examining Global-Scale Controls on Precipitation and Evaluating the Representation of Clouds and Precipitation in Weather and Climate Models

Graeme L. Stephens and Todd Ellis

We will briefly describe mechanisms that control the variability and change of global-scale precipitation and precipitation efficiency using the IPCC FAR transient model experiments to illustrate these mechanisms. We will then probe these mechanisms using new observations from Cloud Sat and the A-Train as a step toward gaining (i) a deeper understanding the relation between cloud and precipitation, especially that associated with the warm rain processes in the real atmosphere, and (ii) the use of these new observations for evaluating the parameterization of precipitation processes in global model.

The Impact of Model Error on ENSO Forecast Performance

Primary Author: Stockdale, Tim

The Impact of Model Error on ENSO Forecast Performance

T. Stockdale ECMWF

Systematic errors in coupled models have a significant impact on seasonal forecasting systems, with errors in SST prediction being the first stage of the problem. Based largely on experience in developing the new ECMWF "System 3" forecasting system, the following areas will be explored:

- estimating the impact of model error vs initial condition error
- the sensitivity of forecasts to errors in the mean state, and the inadequacy of SST as a diagnostic of mean state error.
- the impact of surface current coupling on coupled forecasts, and its relevance for NWP and reanalysis systems.

Exploring Systematic Errors in the Maritime Continent Region in an Atmospheric GCM

Primary Author: Strachan, Jane

Additional Authors: Peter Inness (presenting), Julia Slingo and Gill Martin

Exploring Systematic Errors in the Maritime Continent Region in an Atmospheric GCM

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The islands of the Maritime Continent sit at the heart of the Indo-Pacific Warm Pool. As well as being a region of high tropical SST, the complex local geography of the islands and shallow seas provides additional forcing for convective activity, with a distinctive diurnal cycle of land and sea breezes acting to enhance convective precipitation. Many GCMs have systematic errors in their simulation of precipitation in this region, with far reaching consequences for the global circulation due to errors in the simulation of deep convective heating.

In this study various approaches have been used to understand the development of systematic under-estimation of convective precipitation in this region in the HadGAM1 AGCM. These include

(1) Sensitivity studies to examine the response of precipitation in the region to SST and land-sea mask changes,

(2) A spin-up diagnosis approach to see how the systematic errors develop through the first few days of a climate integration,

(3) the development of a simple "land-sea breeze" parametrization to represent the effect of sub-grid scale circulations in enhancing the surface latent heat flux in the region.

Results from all these approaches will be presented. It will be shown that correcting the precipitation bias over the Maritime Continent in the GCM has a beneficial impact on systematic errors throughout the Warm Pool region and also in the extra-tropics.

Atmospheric Feedbacks Over the Pacific Cold-Tongue: Results From Models and Observations

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Atmospheric Feedbacks Over the Pacific Cold-Tongue: Results From Models and Observations

D.-Z. Sun, T. Zhang, C. Covey, S. Klein, W. Collins, J.J. Hack, J. Kiehl, G.A. Meehl, I. M. Held, and M. Suarez

The equatorial Pacific cold-tongue plays a fundamental role in the heat and carbon balance of the coupled ocean atmosphere system and is a major source region of climate variability. The processes and feedbacks that control the cold-tongue, however, are not well understood. The state-of-the-art coupled general circulation models (GCMs) have a tendency to develop an excessive cold-tongue in the equatorial Pacific. To better understand the feedbacks in this region and in particular to test the hypothesis that the tendency for the coupled GCMs to develop an excessive cold-tongue is due to a weak regulating effect from the model atmosphere, we have quantified the feedbacks in the equatorial Pacific in nine leading atmospheric GCMs using the ENSO signal in that region, and compared with the corresponding calculations from observations.

The net atmospheric feedback over the equatorial Pacific in the two GFDL models is found to be comparable to the observed value. All other models are found to have a weaker negative net feedback from the atmosphere—a weaker regulating effect on the underlying SST than the real atmosphere. Except for the French (IPSL) model, a weaker negative feedback from the cloud albedo and a weaker negative feedback from the atmospheric transport are the two leading contributors to the weaker regulating effect from the atmosphere. The underestimate of the strength of the negative feedbacks by the models is apparently linked to an underestimate of the equatorial precipitation response.

All models have a stronger water vapor feedback than that indicated in Earth Radiation Budget Experiment (ERBE) observations. These results confirm the suspicion that an underestimate of the regulatory effect from the atmosphere over the equatorial Pacific region is a prevalent problem. The results also suggest, however, that a weaker regulatory effect from the atmosphere is unlikely solely responsible for the development of an excessive cold tongue in all models. The need to validate the feedbacks from the ocean transport is therefore highlighted.

Systematic Error in Tropical Cyclone Track Forecasts from Operational Global Models

Primary Author: Takeuchi, Yoshiaki

Systematic Error in Tropical Cyclone Track Forecasts from Operational Global Models

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In 1991, WGNE launched an intercomparison activity on typhoon track forecasts in the western North Pacific area given by operational global NWP models of ECMWF, UKMO and JMA. CMC, DWD, NCEP, BoM, Meteo France and CMA were joined subsequently and the verification area is also expanded to the North Atlantic area, the eastern North Pacific area, the Southern hemisphere, the northern Indian ocean and the central Pacific area. JMA collects the forecast data from each center, compares the detected tropical cyclone positions with the best track and reports the results at the WGNE meeting once every year.

The performance of tropical cyclone track forecasts is measured by forecast error and detection rate. In addition, systematic position error is also monitored by stage, namely before, during and after recurvature. The most recent results for the period of 2005 show the best performance through the past 15 years as a consequence of improvement of a model, data assimilation and new observations, although a single model often fails to forecast in cases of environment with weak steering flow.

Even in that case, a consensus forecast of multi-model ensemble gives better track forecasts by ensemble mean than that by a single model and also gives quantitative reliability of the forecasts.

Performance of New Radiation Parameterization Schemes in the CPTEC-COLA Global Model for Summer Months with Anomaly Precipitation over Central and Southeastern Brazil

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Performance of New Radiation Parameterization Schemes in the CPTEC-COLA Global Model for Summer Months with Anomaly Precipitation over Central and Southeastern Brazil

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The CPTEC-COLA GCM with different solar and thermal radiation schemes is used for a set of ensemble forecasts for normal and anomalously wet and dry summer months from 1997 to 2006 over central and southeastern Brazil. This region is characterized by enhanced convective cloudiness and rainfall in summer related to the South Atlantic convergence zone formation. An offline comparison of the original and two modern solar radiation schemes shows that the modern schemes calculate major atmospheric absorption and hence smaller solar radiative fluxes incident at the surface. The smaller solar radiation incident on the ground causes a decrease in evaporation and hence in convective precipitation rate in the model. The difference between the surface or top-of-the-atmosphere thermal radiative fluxes calculated by original and modern thermal radiation schemes is quite smaller. Nevertheless, the change of the thermal radiation schemes in the model also affects the model results. The surface and top-of-the-atmosphere radiative fluxes simulated by the model with different solar and thermal radiation schemes are compared with the satellite-derived fluxes. The precipitation rates on the ground are compared with Global Precipitation Climatology Project data. In order to quantify the skill of ensemble forecasts various skill scores are calculated for above mentioned region.

Uses of Metrics in the Evaluation and Application of Climate Models

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Uses of Metrics in the Evaluation and Application of Climate Models

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It is difficult to assess the accuracy of model projections of climate change because opportunities for testing the models are limited; past climate changes are either too small or too poorly observed to serve as stringent and straight-forward tests of the models. Consequently, confidence in model veracity stems not primarily from their ability to simulate climate change, but from their ability to simulate the observable phenomena comprising present-day climate. Metrics can serve to summarize various aspects of model performance, but the relevance of proposed metrics to predictive capability remains largely unknown. We describe how metrics for climate models differ from those used in evaluating weather prediction models, and suggest that at present it may be better to rely on a rather large suite of metrics to characterize model skill. Collapsing a suite of metrics to a single "performance index" is possible, but entails a loss of valuable information that likely could leave the index vulnerable to misinterpretation. Furthermore, there is, at present, little practical justification for reducing our evaluation of model performance to a single number. As an alternative, we urge the diagnostic community to join PCMDI in developing a wide variety of metrics useful in evaluating different aspects of model performance. As our understanding of the relationship between skill in simulating present climate and predictive skill improves, the metrics arising from this process might serve as the ingredients for a number of different "performance indices," each one suitable for a specific application.

Combining Multimodel Ensembles -- Coupling Statistics and Expert Judgment

Primary Author: Tebaldi, Claudia

With the increasingly easier access to increasingly larger experimental datasets from multi-model and single-model ensembles, a compelling need arises to develop statistical models in order to rigorously tease out the information these ensembles contain, both in terms of signals and uncertainty bounds. The fundamental assumption of standard statistical analyses of samples is that of independence of the individual data points. Under this assumption, the larger the sample, the more precise the estimate of its central tendency will be. In the world of model experiments, however, expert judgment suggests that the larger the sample of models, the better represented a large range of uncertainty should be. But how do we translate this kind of understanding into formal statistical analyses? I hope to take advantage of the expert audience of this workshop, and in particular of the rich combined experience in thinking about model errors/model dependencies by presenting some results from recent efforts at modeling (statistically) trends and change in projections of regional climate (temperature and precipitation seasonal averages) from the IPCC-AR4 ensemble. My goal is to come up with probabilistic projections by synthesizing the information of the ensemble, but I realize that I'm producing too tight (i.e. optimistically confident) projections, and increasingly so with a growing number of models available. I hope to elicit some constructive criticism and ideas from the modelers, which can be translated into better statistical models for probabilistic future projections.

The Relationship Between the Strength of the ENSO and the Mean Climatology in the HadCM3 Perturbed-Physics QUMP Ensemble

Primary Author: Toniazzo, Thomas

Additional Authors: Matthew Collins and Josephine Brown

The Relationship Between the Strength of the ENSO and the Mean Climatology in the HadCM3 Perturbed-Physics QUMP Ensemble

Thomas Toniazzo and Matthew Collins, and Josephine Brown(2)

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We analyse the differences in the ENSO in a set of 17 coupled integrations with the flux-corrected, 19-level HadCM3 model with perturbed atmospheric parameters. Within this ensemble, the NINO3.4 variability ranges from 0.6K to 1.33 K. The systematic changes in the properties of the ENSO with increasing amplitude confirm that ENSO in HadCM3 is prevalently a surface (or SST) mode. The tropical Pacific SST variability in the coupled integrations correlates strongly with the SST variability in the corresponding ensemble of slab runs with the same atmospheric parameter perturbations. Comparison with the respective coupled ENSO-neutral and slab climatologies indicates low-cloud cover to be an important controlling factor of the strength of the ENSO in HadCM3. This also results in a significant correlation between the ENSO activity and the climate sensitivity to doubling CO₂ within the ensemble. We suggest two mechanisms that may be responsible for the observed behaviour.

Coupled Model Sensitivity of the ENSO to Forcing by Westerly Wind Bursts

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Coupled Model Sensitivity of the ENSO to Forcing by Westerly Wind Bursts

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We present a set of sensitivity experiment performed with the 30-level HadCM3 model in which surface air-sea exchange fluxes in the West Pacific are perturbed by the imposition of westerly wind anomalies with an MJO-like pattern and spectral distribution. Heat and momentum flux perturbations are applied separately and together, and the resulting changes in the statistics of the ENSO and in the dynamics of El-Nino events are evaluated. We expect to carry out additional experiments using a different ocean model component.

Analyses of Systematic Biases in Diurnal Cycle of Surface Albedo and Radiation Budget

Primary Author: Trishchenko, Alexander

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Analyses of Systematic Biases in Diurnal Cycle of Surface Albedo and Radiation Budget

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Surface albedo is a key factor affecting the surface solar radiation budget. An analysis of surface albedo and surface solar radiation budget among the IPCC's AR4 climate model simulations collected by the PCMDI at LLNL, as well as ECMWF and North American Regional Reanalysis(NARR) is conducted to identify issues related to the characterization of surface albedo dependence on solar zenith angle (SZA) and its impact on radiation budget. The dependence of surface albedo on SZA is related to diurnal cycle and, therefore, is important for accurate simulation of surface energy and hydrological cycles. Most models account for the SZA dependence of ocean surface albedo (e.g., the two GFDL models, the three GISS models, INM CM3.0, IPSL-CM4, the two MIROC3.2 models, MRI-CGCM2.3.2, UKMO-HadCM3), but only a few models explicitly include the effect of SZA on land surface albedo (e.g., the two MIRCOC3.2 models, MRI-CGCM2.3.2). The NARR reanalysis and ECMWF schemes also does not include the dependence of land albedo on SZA. The SZA dependence of land albedo is, however, a very well established fact observed both from ground and spaceborne instruments. We compare model results to MODIS albedo retrievals over North America and analyze impact of SZA dependence of surface radiation budget.

Albedo plays an especially important role in the Arctic in summer due to its high values and large spatial variations. There is significant concern about the magnitude and impacts of climate change globally, and particularly, in the Arctic. Observations show that the extent and thickness of ice have decreased in recent decades. However, the properties of ice albedo over the Arctic Ocean are still poorly modeled.

We used 20+ years of satellite data from the 1-km Advanced Very High Resolution Radiometer (AVHRR) archive produced at the Canada Centre for Remote Sensing (CCRS) for climate change impact studies to analyze trends in Western Arctic Ocean ice albedo during the late-summer period. Our analysis revealed that the ice albedo in the North American Arctic Ocean decreased at a rate of 0.06-0.08 per decade in the visible and near-infrared spectral bands from 1985 to 2005. Negative trends in total shortwave albedo were also observed in the ISCCP FD data for the period 1984-1999, although the magnitude is slightly smaller (0.04-0.06 per decade). These decreasing trends in ice albedo correspond to near 20 Wm⁻² increase in surface absorbed monthly mean solar radiation flux during late summer over the 20 year period. This trend is not reproduced satisfactory by the models.

Using Dynamic Regime Composites to Evaluate Model Midlatitude Precipitation Simulations

Primary Author: Tselioudis, George

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Using Dynamic Regime Composites to Evaluate Model Midlatitude Precipitation Simulations

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Michael Bauer, Sigma Space Partners, NASA/GISS

Dynamic compositing techniques are first applied to satellite and ground-based observations to define the full spectrum of variability of the midlatitude precipitation field and to examine the dependence of this field on atmospheric dynamic conditions. Composite analysis requires that we identify and track individual cyclones.

The compositing itself partitions the precipitation field into synoptic-sized regions surrounding tracked cyclones and precipitation falling everywhere else. Among the final products of this process is a map showing the percentage contribution that changes in cyclone activity or behavior make to the regional change in precipitation. Those precipitation changes that can be attributed to cyclone activity are then further diagnosed using the wealth of information that composite analysis provides. These compositing techniques are then applied to output from IPCC AR4 model runs to test whether these climate models reliably express the particular cyclone behaviors that were previously identified as the source of the precipitation change. For this, we use reanalysis results as a proxy for real world cyclone activity and map coincident observations onto these cyclones in an attempt to validate the models. Direct comparisons of the observational and modeling composites allows us to identify deficiencies in the model precipitation distribution, dynamic partition, and variability and provide insights into the physical processes responsible for the identified model errors.

Cloud Water Distribution in the Control Climate and the Response of Clouds to Carbon Dioxide Increase

Primary Author: Tsushima, Yoko

Cloud Water Distribution in the Control Climate and the
Response of Clouds to Carbon Dioxide Increase

Yoko Tsushima

Using CFMIP (cloud feedback model intercomparison project) data, which collects cloud property data for IPCC AR4 AGCMs, we have conducted a multi-model intercomparison of cloud-water for control and doubled carbon dioxide climates. The most notable feature of the differences between the control and doubled carbon dioxide climates is in the distribution of cloud-water in the mixed-phase temperature band. The difference is greatest at mid and high latitudes. We found that the amount of cloud ice in the mixed phase layer in the control climate largely determines how much the cloud-water distribution changes for the doubled carbon dioxide climate. Therefore evaluation of the cloud ice distribution by comparison with data is important for future climate sensitivity studies. Results from global cloud resolving model simulations will be also shown

Impacts of Systematic Model Biases on Intraseasonal Variability of the Asian Summer Monsoon and the Intraseasonal-Interannual Relationship

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Impacts of Systematic Model Biases on Intraseasonal Variability of the Asian Summer Monsoon and the Intraseasonal-Interannual Relationship

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Modes of intraseasonal variation of the Asian summer monsoon in a fully coupled GCM are validated against reanalysis data. The model shows clear evidence of westward propagation in the 10-20 day band. On 30-60 day timescales however, the representation of observed northward propagation is poor. The impact of basic state biases on monsoon behaviour at intraseasonal timescales is assessed using an annual cycle of heat flux adjustments applied to the equatorial Indo-Pacific Ocean surface of a further coupled integration. While the temporal evolution of modes seems unaffected, the spatial representation, particularly of the 30-60 day mode, is improved. EOF analysis is used to investigate the complex relationship between intraseasonal and interannual variation. When the bias is partially corrected through flux adjustment, the spatio-temporal evolution of ENSO is improved, with notable benefits for the monsoon-ENSO teleconnection. Modes of variability common to both integrations at intraseasonal timescales are more dramatically perturbed by ENSO forcing in the flux adjusted experiment, demonstrating that systematic model error not only denigrates interannual variability but also its relationship to intraseasonal behaviour.

The Effect of Doubled CO₂ and Model Basic State Biases on the Monsoon-ENSO System: The Mean Response and Interannual Variability

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The Effect of Doubled CO₂ and Model Basic State Biases
on the Monsoon-ENSO System: The Mean Response and Interannual Variability

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The impact of doubled CO₂ concentration on the Asian summer monsoon is studied using a coupled ocean-atmosphere model. Both the mean seasonal precipitation and its interannual variation are found to increase in the future climate scenario presented. Systematic errors in current climate simulations of the coupled system prevent accurate representation of the monsoon-ENSO teleconnection, of prime importance for seasonal prediction and for determining monsoon interannual variability. By applying seasonally varying heat flux adjustments to the tropical Pacific and Indian Ocean surface in the future climate simulation, some assessment can be made of the impact of systematic model error on future climate scenarios. In simulations where the flux adjustments are implemented, the response to climate change is magnified, with the suggestion that systematic biases may be masking the true impact of increased greenhouse gas forcing. The teleconnection between ENSO and the Asian summer monsoon remains robust in the future climate, although the relationship takes on more of a biennial character in the flux adjusted simulation.

Systematic biases have more impact on the teleconnection than variations in CO₂ forcing. Wide decadal-timescale variations in the amplitude of the monsoon-ENSO relationship despite the absence of external forcing suggest that recent changes in the observed record may represent internal variation.

Problems in the Representation of the Antarctic Climate in Coupled GCMs

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Problems in the Representation of the Antarctic Climate in Coupled GCMs

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The simulation of the Antarctic climate in GCMs presents a number of problems. The steep orography at the edge of the continent and along the Antarctic Peninsula is difficult to represent realistically with the relatively coarse resolution of the current models. The smoothing applied to the orography results in orographic enhancement of the precipitation over the ocean giving a negative bias to the surface mass balance across the continent.

The coastal region is characterised by complex air-sea-ice interactions that are also difficult to represent realistically. Increasingly sophisticated sea ice dynamics parameterisations have been included in many models over the last few years. However, experiments suggest that errors in the broadscale near-surface flow can induce large errors in the sea ice extent regardless of the sea ice parameterisation scheme used. The third generation Hadley Centre coupled climate model (HadCM3) has a large negative sea ice anomaly over the Amundsen-Bellingshausen Sea (ABS) just to the west of the Antarctic Peninsula. This is a very important region to have represented correctly as temperatures on the western side of the peninsula have increased more than anywhere else on Earth over the last 50 years. The sea ice anomaly is a result of a negative MSLP errors over the ABS. This in turn has been attributed to positive sea-surface temperature errors over the tropical, eastern sides of the major ocean basins as a result of there being too little cloud.

The IPCC Assessment Report 4 (AR 4) simulations of the Earth's climate over the last 50 years and projections for the next century provide an extremely valuable resource for investigating past climate change and assessing possible changes in the future. We have developed a scheme to weight the future projections from the 20 IPCC models based on their performance in simulating past Antarctic climate variability. The strengths and weaknesses of the Antarctic simulations of the models will be discussed and the impact of the weighting scheme on the projections will be presented.

The Impact of a Dynamic CAPE Timescale on Precipitation Variability and Distribution in the Hadley Centre GCM

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Pier Luigi Vidale and John Donners

The Impact of a Dynamic CAPE Timescale on Precipitation Variability and Distribution in the Hadley Centre GCM

The parameterization of cumulus precipitation in a climate model impacts both the distribution and variation of precipitation and the model's climate sensitivity. In the UK Met Office Unified Model (UM), the strength of atmospheric convection depends on the convective available potential energy (CAPE), as controlled by a "CAPE timescale". Experiments show that if a short CAPE timescale is chosen, the convection shows an unrealistic, intermittent behaviour, also resulting in poor radiation cloud interaction, especially over the tropical oceans. Further, convection is very vigorous during single timesteps and on average maximum convective precipitation starts too early in the diurnal cycle over land.

In this presentation we show results from two experiments: (a) in the standard configuration, the CAPE timescale depends linearly on relative humidity, but the CAPE timescale is limited to be at most 1 hour; (b) the CAPE timescale depends inversely on the ambient vertical velocity, allowing weaker convection to develop, with a CAPE timescale of up to 6 hours in the limit of no vertical velocity. The intermittent behaviour of convection decreases and convective clouds are more abundant in the second experiment, because the convection is allowed to be less intense. The weaker convection in the second experiment delays the diurnal cycle of convective precipitation by a few hours both over land and ocean. Precipitation variability increases over several land regions, which indicates that the weaker convection allows moist static energy build up over land, before an early afternoon release by convection. The poor timing and variability of precipitation in the standard UM configuration had already been shown to cause unrealistically low coupling between land surface and atmosphere; we argue that improving precipitation distribution also improves plant physiology indicators.

Temperature and Humidity in IPCC AR4 Models: An Assessment Using AIRS Observations

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Additional Authors: Brian Jon Soden

Temperature and Humidity in IPCC AR4 Models: An Assessment Using AIRS Observations

Viju Oommen John and Brian Jon Soden

An evaluation of temperature and humidity fields in the coupled IPCC AR4 models has been carried out using Atmospheric Infrared Sounder(AIRS) observations. Zonally averaged, vertical profiles of temperature, specific humidity, and relative humidity from 20th century climate (20C3M) simulations are used in this study. Temperature field in the models show a cold bias through out the troposphere, but for most of the models, it is less than 2 K. The differences go up to 10 K at tropopause regions at high latitudes. In case of specific humidity, models show moderate dry bias (less than 30%) in lower troposphere, where as they show significantly large wet bias (even 100% and more) in middle and upper troposphere. Moreover, there is a large difference in magnitude and bias patterns among the models. These differences in temperature and specific humidity lead to a large difference relative humidity in the models. The presentation will discuss in detail about these biases in the models compared to observations and their implications on climate simulations.

Systematic Errors in Tropical Cloud Distribution and Climate Sensitivity

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Systematic Errors in Tropical Cloud Distribution and Climate Sensitivity

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Vertical distribution of tropical cloudiness in AR4 models is studied in connection with model climate sensitivity. Model climate sensitivity seems to be correlated with the height of maximum of high cloudiness and the amount of PBL cloudiness. Models with high sensitivity have maximum of high cloudiness at 100-200 hPa, and the amount of PBL cloudiness is low. Models with low sensitivity have maximum of high cloudiness at 250-300 hPa, and the amount of PBL cloudiness in these models is high. An attempt is made to connect model vertical cloud distribution with vertical profile of relative humidity and to estimate natural climate sensitivity using observed profile of relative humidity.

US CLIVAR MJO Working Group: MJO Simulation Metrics

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US CLIVAR MJO Working Group: MJO Simulation Metrics

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In spring 2006, US CLIVAR established the Madden-Julian Oscillation (MJO) Working Group (MJOWG). The formation of this 2-year limited lifetime WG was motivated by: 1) the wide range of weather and climate phenomena that the MJO interacts with and influences, 2) the fact that the MJO represents an important, and as yet unexploited, source of predictability at the subseasonal time scale, 3) the considerable shortcomings in our global climate and forecast models in representing the MJO, and 4) the need for coordinating the multiple threads of programmatic and investigator level research on the MJO. Near-term tasks involve the development of metrics for assessing model performance in both climate simulation and extended range/subseasonal forecast settings, as well as designing and coordinating multi-model experimentation and analysis to diagnose and improve model shortcomings and assess MJO predictability characteristics and present-day prediction skill. In addition, the WG will help to coordinate MJO related activities across other programmatic bodies (e.g., GEWEX, International CLIVAR, Thorpex) and will explore the applications and potential user base for subseasonal predictions based on the MJO. The purpose of this presentation is to make the community aware of these activities and more specifically to present the metrics that have recently been developed for assessing model performance in simulating the MJO. Finally, we seek input and will be soliciting participation in a workshop being planned for mid-late 2007 tentatively titled "New Thinking, Tools & Resources for Assessing & Improving the MJO". The workshop will focus on the multi-scale and vertical structure of the MJO, the utility of both forecast multi-scale modeling frameworks for improving MJO model representation, the vast new satellite and other resources for studying the MJO, and application of the model metrics. For additional details, see www.usclivar.org/Organization/MJO_WG.html.

How are Seasonal Prediction Skills Related to Models Systematic Errors in Annual Cycle?

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How are Seasonal Prediction Skills Related to Model's Systematic Errors in Annual Cycle?

Bin Wang and June-Yi Lee

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Knowledge of the models' performance in simulating and forecasting seasonal mean states is necessary for assessing models' capability in predicting seasonal anomalies. We assessed the performances on annual cycle(AC) in APCC/CliPAS and DEMETER models' 21-year (1981-2001) hindcast products. These models consist of 13 coupled and 5 uncoupled ones. The metrics used for assessing mean states include the mean climate and the first two modes of annual variation, i.e., the solstice monsoon mode and the equinox asymmetric mode. The following questions are addressed: (1) How well do the current models forecast the annual mean and seasonal cycle? (2) What are the common biases in the coupled models and stand-alone atmospheric models forced by predicted SST? (3) Are the skills in forecasting the mean state and seasonal cycle related to the models' skills in seasonal prediction?

It is shown that the current coupled models can reproduce the annual mean and the leading AC mode of precipitation reasonably well, while they have difficulty to simulate the 2nd AC mode, especially over the Indian Ocean and western North Pacific (WNP). The uncoupled models have large positive biases in the leading AC mode over the WNP where the negative feedbacks from the atmosphere to ocean were missed.

Over the WNP region, the most coupled models capture the mean and AC more realistically than uncoupled ones, but they tend to underestimate the precipitation amount and the interannual variability, thus degrading seasonal prediction skills. The assessments were extended to the important Asian sub-monsoon domains as well. Even though the coupled models have difficulty in capturing climatological intraseasonal variation, they can capture the climatological onset and withdraw dates realistically, especially over the Indian monsoon region. It is shown that the seasonal prediction skills are positively correlated with their performances on both the annual mean and annual cycle in the coupled climate models.

The Warm Bias in the Southeastern Pacific in the NCEP CFS Model

Primary Author: Wang, Wanqiu

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The Warm Bias in the Southeastern Pacific in the NCEP CFS Model

Wanqiu Wang, Pingping Xie, Wayne Higgins, Meghan Cronin, Phillip Arkin, and Robert Weller

As in many contemporary coupled atmosphere-ocean general circulation models, there exists a sea surface temperature(SST) warm bias in the Southeastern Pacific (SEP) in the National Centers for Environmental Prediction (NCEP)coupled Climate Forecast System (CFS) model. This study examines the formation of this warm bias, its association with the deficiency of model-produced stratus clouds, and its impact on the model's time-mean state and interannual variability. Questions we will address include:

- (1) Where does the warm bias start, how does it evolve in space, and how quickly does it develop?
- (2) How does the warm bias relate to the deficiency of model-produced stratus clouds, and what is the contribution of the associated excessive surface radiation fluxes?
- (3) What is the role of oceanic dynamics in the evolution of the warm bias?
- (4) What are the impacts of the warm bias on the mean state of the model and on its interannual variability?

These questions are addressed based on outputs from a suite of CFS integrations, including: (a) retrospective 9 month seasonal forecasts from realistic atmospheric and oceanic initial conditions from each month of 1981-2004,(b) long-term multi-decade free simulations, (c) experimental free simulations with mean surface radiation errors over the SEP area [30°S-0°; 90°W-68°W] corrected, and (d) simulations with the uncoupled oceanic component of the CFS with and without mean surface radiation errors over the SEP area.

The North Pacific Climate Variability as Simulated by Coupled Atmosphere-Ocean Models

Primary Author: Wang, Muyin

The North Pacific Climate Variability as Simulated by Coupled Atmosphere-Ocean Models

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The major mode of variability in North Pacific sea surface temperature (SST) fields is studied based on model control runs and 20c3m simulations. Among the 22 models available at the PCMDI archive center, 18 have complete archives for the pre-industrial control run (PIctrl), the 20th century climate simulation (20c3m) and the forecast for 21st century under the A1B scenario. Based on spatial pattern correlations, we find that 14 models replicate the spatial structure in the leading mode of the decadal SST variation, the Pacific Decadal Oscillation (PDO) in their 20c3m and control run simulations. Of these 14 model runs, 11 have power spectra in their leading modes resembling that of the PDO, and 9 also have the proper magnitude of the temporal variability. Other parameters (sea level pressure, winds, sea ice) related to the climate system are also examined. This exercise indicates that a subset of the IPCC models which are validated against 20th century data form a more reliable basis for future climate projections.

Historical Climate Simulations over East Asia

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Historical Climate Simulations over East Asia*

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(October 31, 2006)

The effort of historical climate reconstruction over China, conducted by IGSNRR under the collaborative agreement Climate Sciences between the U. S. Department of Energy and the China Ministry of Sciences and Technology, has compiled several high resolution 1,000-2,000 years proxy climate data sets. The data have been used to study long-term climate variability, and more recently to evaluate GCM simulations of East Asia climate, with the notion that confidence in using the models for future climate prediction will be much enhanced if the same models possess the ability to simulate both the present and past climates. However, there are issues in comparing model simulations with proxy data. For example, the proxy data are area averaged anomalies, while the model simulations, at present, are quantitative in coarse-grid resolution. In addition, the proxy data include implicitly the climate forcing factors (solar variation, volcanic aerosols, greenhouse gases, etc.) while model simulations used the prescribed forcing with uncertainties.

Here we present findings of a comparative study of the proxy data and several coupled model simulations including NCAR CCSM and BCC models for historical periods, and IPCC AR4 models for the past 150 years. In addition to climate variability, we also examine the spatial and temporal evolution of temperature and precipitation patterns for two periods, 1635-1646 and 1808-1819 during which large volcanic eruptions occurred. Note that during the first period eastern China experienced exceptional and persistent droughts while substantial cooling was recorded during the second period. To understand the volcanic forcing and climate responses, sensitivity experiments using SUNY regional climate model with CCSM simulations as the lateral boundary conditions were also conducted.

*The Third JSC/CAS Working Group on Numerical Experimentation (WGNE) Workshop on Systematic Errors in Climate and NWP Models, San Francisco, February 12-16, 2007

Systematic Performance of the NCEP Climate Forecast System

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Systematic Performance of the NCEP Climate Forecast System

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Twice a day the operational NCEP Climate Forecast System (CFS) produces 9 month forecasts. The CFS is a fully coupled atmosphere-land-ocean model. The atmospheric component is the NCEP Global Forecast System (GFS) model operational in 2003. It is intended that future versions of the CFS will use the same atmospheric model as the GFS. Development of an improved version of the CFS is underway; extended AMIP and CMIP integrations of different versions of the CFS are being carried out and evaluated. This paper will focus on the results of extended AMIP and CMIP integrations.

The currently operational CFS has T62 spectral resolution with 64 layers in the vertical. In developing the CFS, it was found that increasing the number of vertical layers from 28 to 64 layers in CMIP integrations produced a substantially more realistic simulation of the equatorial Pacific, reducing a cold bias in SST along the equator. The 28 level model had much more precipitation in the east Pacific ITCZ, too strong surface stress over the equatorial Pacific and too much upwelling near the equator in the east Pacific. (The number of vertical layers had much less effect on the performance of AMIP integrations.) However, increased vertical resolution also resulted in decreased stratus clouds and increased warm SST biases in the eastern subtropical oceans.

The NCEP CFS has stronger surface radiative fluxes, evaporation and precipitation than in independent estimates. On-going experiments with higher horizontal resolution (T126) in the atmosphere suggest that surface stresses in the eastern equatorial Pacific are somewhat too weak. Surface fluxes and cloudiness also appear sensitive to horizontal resolution.

The currently operational GFS atmospheric model has been tested at T126 resolution in extended CMIP integrations. Both the operational CFS and GFS produce global cooling of 2-meter air temperature in extended coupled integrations, but the GFS produces more severe cooling and a drier atmosphere, reflecting reductions in vertical diffusion. Replacing the sigma vertical coordinate with a hybrid vertical coordinate seems to improve the GFS performance.

Systematic Errors in the NCEP Global Forecast System

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Systematic Errors in the NCEP Global Forecast System

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The U.S. National Weather Service has generated operational medium-range forecasts from global analysis/forecast systems since the 1970's. Currently 16-day forecasts are generated four times a day. The skill of 5-day forecasts of 500 hPa heights has doubled in 2 decades. Two decades ago the GFS exhibited useful forecast skill out to 5 days for 500 hPa heights; today it exhibits useful skill out to 7.5 days. Examination and reduction of systematic errors have helped to improve global forecasts. This talk examines reductions in systematic errors over the last two decades in the GFS, the effect of recent improvements in the treatment of diffusion and mountain forcing and recent work on short-range forecast errors and comparisons of systematic errors in the GFS and other operational global forecast systems.

Examining short-range forecast errors offers insight into model problems before nonlinear effects obscure the source of errors, but is frequently complicated by uncertainty whether the short-range errors reflect model or analysis problems. Comparison of analyses and short-range forecasts to observations can help, but is limited by errors in the observations themselves and by the uneven distribution of observations.

Comparison of time-averaged analyses and forecasts by the GFS to the same fields from other operational numerical weather prediction centers has also been used to expose problems in the GFS. ?Transplant? experiments in which analyses from one operational center are used to initialize forecasts with the global model of another center are run to clarify the relative roles of the assimilation system and forecast model in causing model errors. Significant time-mean differences in the tropical analyses and forecasts between the GFS and other centers were found to reflect differences in the forecast model rather than the assimilation.

Two recent short-range systematic errors in the GFS have been negative height errors over orography and a weakening of the jet maxima. Enhanced mountain blocking and reduced diffusion in the free atmosphere were tested and found to reduce these errors and to improve forecast skill in the Northern Hemisphere. These changes were implemented in mid-2005. Recent problems in the Southern Hemisphere are currently being investigated.

Systematic Errors in GCM Simulated Radiation Budgets Inferred from Surface Observations

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Systematic Errors in GCM Simulated Radiation Budgets Inferred from Surface Observations

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Substantial uncertainties still exist on the distribution of radiative energy within the climate system, and accordingly in General Circulation Models. For example, absorption of solar radiation in the atmosphere of current GCMs varies by more than 30% even under cloud-free conditions. To constrain these uncertainties, we use radiation observation at the surface from the Global Energy Balance Archive (GEBA) and Baseline Surface Radiation Network (BSRN) located at ETH Zurich. These data are used to systematically assess the radiative fluxes of various GCMs, representing almost two decades of model development, from the atmospheric model intercomparison projects AMIP I and AMIP II to the state-of-the-art models participating in the 4th IPCC Assessment Report (AR4).

Results show that models up to now tend to overestimate the solar irradiance, due to a lack of shortwave absorption in the atmosphere. The excessive surface insolation is also found under cloud-free conditions in many models, while improvements are found in some of the latest AR4 models with higher atmospheric absorption. The most difficult component to model in the longwave is the downward longwave flux at the surface. Accordingly, large discrepancies exist in the global means of this component in the GCMs, both under all sky and clear sky conditions. A comparison with available observations suggests that the IPCC AR4 GCMs tend to systematically underestimate the longwave downward flux. The downward longwave flux at the surface is a particularly interesting component in the context of climate change, as it is most directly affected by changes in atmospheric greenhouse gases. GCMs predict the downward longwave flux to undergo the largest changes of all energy and radiation balance components. Observed changes in these fluxes are in line with the model predictions, increasing confidence in our understanding of the greenhouse effect.

Recent evidence suggests that the amount of solar radiation reaching the earth surface is not stable over time but exhibits significant decadal variations. These variations, in addition to the changes in longwave radiation induced by alterations in greenhouse gases, cause changes in radiative forcings which may significantly affect surface climate. Observations suggest that surface solar radiation, after decades of dimming, reversed into a brightening since the mid 1980s at widespread locations. These changes are in line with a recovery of atmospheric transparency, possibly related to reduced aerosol loadings due to air pollution control and the breakdown of industry in formerly Communist countries. Current GCMs typically do not represent aerosol effects with a degree of sophistication to capture these effects. Here we use a special version of the Max Planck Institute for Meteorology GCM (ECHAM5-HAM), which includes aerosol effects in more detail than in most other GCMs. Due to the improved treatment of aerosol effects, the model is able to reproduce the observed trend reversal under cloud-free conditions realistically.

Recent related references:

Wild, M., Ohmura, A., Gilgen, H., and Rosenfeld, D., 2004: On the consistency of trends in radiation and temperature records and implications for the global hydro-logical cycle. *Geophys. Res. Lett.*, 31, L11201, doi: 10.1029/2003GL019188.

Wild, M., 2005: Solar radiation budgets in atmospheric model intercomparisons from a surface perspective. *Geophys. Res. Lett.*, 32, L07704, doi:10.1029/2005GL022421.

Wild, M., Gilgen, H., Roesch, A., Ohmura, A., Long, C., Dutton, E., Forgan, B., Kallis, A., Russak, V., and Tsvetkov, A., 2005: From dimming to brightening: Decadal changes in solar radiation at the Earth's surface. *Science*, 308, 847-850.

Wild, M., Long, C.N., and Ohmura, A., 2006: Evaluation of clear-sky solar fluxes in GCMs participating in AMIP and IPCC-AR4 from a surface perspective. *J. Geophys. Res.*, 111, D01104, doi:10.1029/2005JD006118.

Wild, M., and Roeckner, E., 2006: Radiative fluxes in ECHAM5. *J. Climate*, 19, 3792-3809.

CMIP3, IPCC, and the Earth System Grid: Center for Enabling Technologies (ESG/CET)

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Additional Author: Robert Drach

ESG-CET's objective is to build an infrastructure capable of dealing with the petascale data management and analysis challenges of the next five years. To be used extensively by the research community, we believe that this infrastructure will expedite science and provide a collaborative environment to advance research in a way that can only be done by this proposed framework. This framework is based on some components used in the current SciDAC 1 ESG-II (which delivered data that were the basis for some 200 journal articles in the past two years); but it will be redesigned to fit a grander and more distributed up-scaled vision that will encompass much more of the user community. To aid in fulfilling our analysis requirements, we have established collaborations with several SciDAC or other outside projects. Many of these collaborations will rely solely on us to deliver their diverse tools and products (e.g., analysis, visualization, knowledge discovery tools, etc.) to the research community. By enhancing our connections with these proposed SciDAC efforts and by continuing to align ourselves with the climate research community, we will address specific scientific needs relating to data management and analysis over the next five years. As a representative sample of these scientific needs, we will focus on requirements generated by the next IPCC assessment, the CCSM and its related SciDAC activities, and the Climate Science Computational End Station. These three projects are well aligned with the rest of the climate community and will provide a focus for ESG-CET efforts and future development. More precisely, our project's objectives are to: Connect a large number of outside researchers with geographically distributed large climate model archives through client-server infrastructure using middleware components, Provide scientists with easy-to-use advance data analysis tools for their science and research, and Encourage and promote ESG-CET by enabling the community to contribute to objectives 1 and 2, as well as their integration.

Initial Tendencies of Cloud Regimes in the Met Office Unified Model

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Keith Williams and Malcolm Brooks

The Met Office Unified Forecast-Climate Model is used to compare the properties of simulated climatological cloud regimes with those produced in short-range forecasts initialised from operational analyses. The regimes are defined as principal clusters of joint cloud top pressure -- optical depth histograms. In general, the cloud regime properties are found to be similar at all forecast times, including the climatological mean. This suggests that weaknesses in the representation of fast local processes are responsible for errors in the simulation of the cloud regimes. The increased horizontal resolution of the model used for numerical weather prediction generally has little impact on the cloud regimes, although the simulation of tropical shallow cumulus is improved, whilst the relative frequency of tropical deep convection and cirrus compare less favourably with observations. Analysis of initial temperature tendency profiles for each cloud regime indicates that some of the total temperature tendency which leads to a systematic bias in the model climatology is associated with a particular cloud regime.

Constraining the Range of Climate Sensitivity through the Diagnosis of Cloud Regimes

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Additional Authors: George Tselioudis

Constraining the Range of Climate Sensitivity through the Diagnosis of Cloud Regimes

Keith Williams and George Tselioudis

The radiative feedback from clouds remains the largest source of variation in climate sensitivity between general circulation models (GCMs). This study aims to understand and evaluate the climate change response in an ensemble of structurally varying GCMs in the context of cloud regimes. It is found that the present-day characteristics of the cloud regimes contribute to the spread of the climate change response. By evaluating the simulated regimes against observational data, the variance of the global cloud radiative response, and hence the range of climate sensitivity, can be reduced. Therefore, the method provides an observational metric with which to assess a climate model, which is demonstrated to be relevant for the model climate sensitivity.

Addressing Tropical Biases in GFDLs Global Coupled Climate Models

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Addressing Tropical Biases in GFDL's Global Coupled Climate Models

Global coupled GCMs from the Geophysical Fluid Dynamics Laboratory (GFDL) have performed well in recent model intercomparisons connected with the IPCC Fourth Assessment. But like all current CGCMs run without flux adjustments, the GFDL models retain substantial biases in their simulated tropical climate and variability. GFDL has taken three new avenues to meet these challenges. First, intercomparisons with our peer models in the IPCC AR4 archive, which are clarifying key sensitivities -- such as ENSO's sensitivity to the spatial structure of the wind stress response to SST anomalies. The second avenue is a suite of automated diagnostics -- including climatological comparisons with multiple observational products, ENSO regressions to measure air-sea coupling and heat flux damping, correlations with local SSTs to gauge local feedbacks, and wavelet diagnostics to evaluate model spectra - that provide helpful summary metrics for rapid assessment of coupled and uncoupled simulations.

The third approach is a hybrid coupled model framework -- consisting of the CGCM ocean component coupled to a statistical atmosphere that has been fit to a long run of the CGCM -- which provides an efficient and controllable testbed for isolating coupled sensitivities, intercomparing CGCMs, evaluating new oceanic and atmospheric components, and exploring how climatological biases affect model variability. Together, these three avenues are establishing clear links among CGCMs, intermediate models, and ENSO theory, advancing our understanding of tropical climate and variability and ultimately helping to improve the models used to simulate and predict them.

Validation of Global Weather Forecast and Climate Models over the North Slope of Alaska Using ARM M-PACE Data

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Data collected from the ARM Mixed-Phase Arctic Cloud Experiment (M-PACE) field campaign over the North Slope of Alaska (NSA) in October 2004 have been used to validate Arctic clouds and radiation simulated by the ECMWF weather forecast model and by two U. S. climate models, the NCAR Community Atmosphere Model (CAM3) and the GFDL Atmosphere Model (AM2). The two climate models were diagnosed in a comparable weather-forecasting framework developed for the CCPP-ARM Parameterization Testbed (CAPT), a joint effort of ARM and DOE's Climate Change Prediction Program (CCPP).

All the models show skill in predicting various cloud types observed during M-PACE; however they underpredict cloud amount in the early period of the experiment when both multilayered and boundary-layer mixed-phase clouds are present. During this period, the simulated cloud bases by the two climate models (CAM3 and AM2) are too low compared to the observations. Large error is also seen in the simulated cloud microphysical properties.

The ARM M-PACE data also reveal deficiencies in the model simulations of radiative fluxes at the surface and the top of the atmosphere that are associated with the errors in their predicted cloud fields. At the times of the boundary layer clouds, CAM3 and ECMWF considerably overestimate the outgoing longwave radiation at the top of the atmosphere and substantially underestimate the downwelling longwave radiation at the surface while AM2 shows a good agreement with the observations in these fields. Errors in the model cloud and radiation fields also can have a large impact on the simulated surface energy budget. For example, the ECMWF model exhibits a much larger energy loss (-21 W/m^2) than the observed (-9.6 W/m^2) at the surface during the M-PACE period.

Convectively Coupled Equatorial Waves in the Hadley Centre Climate Models

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Convectively Coupled Equatorial Waves
in the Hadley Centre Climate Models

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A methodology for diagnosing convectively coupled equatorial wave behaviour is applied to output from Hadley Centre climate models. Structures and propagation characteristics of tropical convection and equatorial waves and their coupled behaviour in the models are examined and evaluated based on a comprehensive study of observed convectively coupled equatorial waves. The extent to which the models are able to represent the coupled waves found in real atmospheric observations is investigated. It is shown that convection in these models contains very limited variance coincident with equatorial Kelvin wave and mixed-Rossby gravity waves. Although these models can simulate the dynamical structures of equatorial waves, the coupling of these waves with convection, particularly in equatorial regions, is deficient. In addition, modelled equatorial waves and associated convection tend to have lower frequency and slower phase speed than observed. Conclusions will be drawn over the possible need to develop new convective parametrizations that will have improved coupling with other parametrizations and with the dynamics.

Dependence of Land Surface Albedo on Solar Zenith Angle: ARM and SURFRAD Observations, MODIS Retrieval and NCEP NWP Model Parameterization

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Dependence of Land Surface Albedo on Solar Zenith Angle: ARM and SURFRAD Observations, MODIS Retrieval and NCEP NWP Model Parameterization

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This study examines the dependence of surface albedo on solar zenith angle (SZA) over snow-free land surfaces using the intensive observations of surface shortwave fluxes made by the Department of Energy Atmospheric Radiation Measurement (ARM) Program and the National Oceanic and Atmospheric Administration Surface Radiation Budget Network (SURFRAD) at ten ground stations in 1997-2005. Results are used to evaluate the National Centers for Environmental Prediction (NCEP) Global Forecast Systems (GFS) parameterization and the MODIS-based satellite retrievals as described in a few recent studies. The influence of clouds on surface albedo and the albedo difference between morning and afternoon observations are also investigated. A new approach is taken to partition the observed upward flux so that the direct-beam and diffuse-beam albedos can be separately computed. The study focused first on the ARM Southern Great Plains Central Facility site. It is found that the diffuse-beam albedo prescribed in the NCEP GFS matched closely with the observations. The direct-beam albedo parameterized in the GFS is largely underestimated at all SZAs. The parameterizations derived from the MODIS product largely underestimated the direct-beam albedo at large SZAs and slightly overestimated it at small SZAs. Similar results are obtained from the analyses of observations at other stations. Attempts are made to improve numerical model algorithms that parameterize the direct-beam albedo as a product of the direct-beam albedo at SZA= 60 deg (or the diffuse-beam albedo), which varies with surface type or geographical location and/or season, and a function that depends only on SZA. Such functions derived from nine ARM and SURFRAD stations show similar dependencies on SZA. These stations are situated on pasture, grassland, cropland, bare soil and rocky desert. A method is presented for computing the direct-beam albedos over all snow-free land points without referring to a particular land-cover classification scheme, which often differs from model to model.

Diurnal Patterns of Monsoon Rainfall over the Indochina Peninsula- Observations and Model Simulations -

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Diurnal Patterns of Monsoon Rainfall over the Indochina Peninsula
- Observations and Model Simulations -

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The Indochina Peninsula and surrounding oceans are known as an area of the distinct seasonal march and vigorous diurnal variations of rainfall. The diurnal variations could be one of essential components of water cycle. However, the diurnal variations of rainfall and its seasonal march have not yet been made clear due to sparseness of observational data and few modeling studies on high temporal-resolution in that region. This paper examines dynamics of diurnal variations of rainfall and its systematic errors in models during the summer rainy season.

Diurnal patterns of rainfall over the Indochina Peninsula were investigated, using in situ and satellite observations. A strong afternoon/evening maximum of rainfall prevails along the mountain ranges. Over the offshore of the Indochina Peninsula, mid-night/early-morning maximum of rainfall is observed. These are consistent with the typical features of diurnal variations of rainfall over the Tropics. Interestingly, the mid-night maximum of rainfall exhibits around the Khorat Highland, which is located in inland of the Indochina Peninsula.

To simulate the typical diurnal patterns of rainfall over the Indochina Peninsula, the Weather Research and Forecasting (WRF) model was used with nested grid. The two grids are integrated for a period of 1 month in the rainy season. It was found that the diurnal variations of rainfall are strongly affected by large-scale atmospheric fields. When there is no large-scale disturbance, the some known aspects of diurnal patterns of rainfall can be simulated. Simulated mid-night maximum of rainfall over the Khorat Highland is consistent with the climatological diurnal patterns of rainfall. The evening rainfall over the mountain ranges is likely to be associated with the mid-night maximum of rainfall over the Khorat Highland. The mechanism of the mid-night maximum of rainfall over the Khorat Highland would be discussed.

The seasonal changes of atmospheric circulation and surface conditions are prominent in the summer rainy season over the Indochina Peninsula. The diurnal patterns of rainfall are most likely to be affected by changes in large-scale seasonal circulation and in surface conditions, but models also show different sensitivity to these boundary conditions.

Transient Climate Response and Reproducibility of Present Climate States by Atmosphere-Ocean Coupled General Circulation Models

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Transient Climate Response and Reproducibility of Present Climate States by Atmosphere-Ocean Coupled General Circulation Models

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The present study is an investigation of the relationship between transient climate responses (TCR) to increases in greenhouse gases and the reproducibility of present climate states by atmosphere-ocean coupled general circulation models (AOGCM). In particular, we focused on ocean heat uptake (OHU), which plays an important role in determining TCR.

The Model for Interdisciplinary Research on Climate (MIROC) is an AOGCM developed by the Center for Climate System Research (CCSR) at the University of Tokyo, the National Institute for Environmental Studies (NIES), and the Frontier Research Center for Global Change (FRCGC). MIROC 3.2 has two versions with different resolutions, high (Hi-Res, atmospheric horizontal resolution of approximately 100 km) and medium (Mid-Res, approximately 300 km), and the TCR of the former is higher than that of the latter. According to Yokohata et al. 2006, one of the reasons for the different TCR in the two versions is caused by the difference in OHU: Since the Hi-Res version has stronger stratification and thinner mixed layer depth (MLD) compared to the Mid-Res version, it has a smaller OHU and thus a larger TCR. This result suggests that MLD simulated by climate models can play an important role in determining OHU. Therefore, models with more realistic MLD may provide a more reliable estimation of OHU in future climate projections.

The present study examined the relationship between OHU and MLD simulated by the climate models used in the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (AR4). In addition, we studied whether uncertainty regarding OHU in future climate projections can be constrained by examining the ability of the climate models to reproduce the MLD of current climate states. Finally, a similar analysis was performed for other climate feedback processes which play an important role in determining TCR.

Reference

Yokohata et al. (2006), Different transient climate responses of two versions of an atmosphere-ocean coupled general circulation model. *Geophys. Res. Lett.* (forthcoming)

Simulations of the 100 hPa South Asia High and Precipitation over the East Asia with IPCC Coupled GCMs

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Simulations of the 100 hPa South Asia High and Precipitation over the East Asia with IPCC Coupled GCMs

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ABSTRACT

The South Asia High (SAH) and precipitation over the East Asia simulated by 11 coupled GCMs associated the forthcoming Intergovernmental Panel on Climate Changes(IPCC) 4th Assessment Report are evaluated. The seasonal behavior of the SAH is presented for each model. Analyses of the results show that all models are able to reproduce the seasonal cycle of the SAH. Locations of the SAH center are also basically reproduced by these models. Most of the models underestimate the intensity and the extension of coverage all year round except NCAR CCSM3. The anomalous SAH can be divided into east and west modes according to its longitude location in summer on the interannual time scale, and the composite anomalies of the observed precipitation for these two modes tend to have opposite sign over the East Asia.

However, only several coupled GCMs can simulate the similar relationship between rainfall and SAH as observed, which may be associated with the bias in simulation of the subtropical anticyclone over West Pacific (SAWP) at 500hpa. In fact, we found that any coupled GCM, which can reproduce the reasonable summer mean state of SAWP and southward (northward) withdrawal (extension) for the east (west) mode of SAH as observed, will also simulate similar rainfall anomaly pattern for the east and west SAH modes over the East Asia. Further analysis indicates that the observed variations in the SAH, SWAP and rainfall are closely related to the sea surface temperature (SST) over the equatorial tropical Pacific, Particularly, some models can not simulate the SAWP with extending northward in west mode and withdrawing southward in the east mode, which may be related to weak major El or La events. The abilities of the coupled GCMs to simulate the SAWP and ENSO events associate partly with reproducing the observed relationship between SAH and rainfall anomaly over the East Asia.

Using a Two-Oscillator View to Examine the CGCM Deficiency in ENSO Simulations

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Using a Two-Oscillator View to Examine the CGCM Deficiency in ENSO Simulations

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By analyzing ENSO persistence barrier in the past four decades (1958-2001), we propose that the ENSO cycle consists of two different oscillators: a central Pacific oscillator which is forced by atmospheric forcing and an eastern Pacific oscillator which is resulted from the air sea interaction involving the thermocline variation in the cold tongue. When the basic state (such as the thermocline depth) changes, the eastern Pacific oscillator is affected and its onset time changes from decadal to decade. But the western Pacific oscillator is not sensitive to the thermocline depth and maintain its onset time in Spring. As a result, ENSO SST anomalies propagates from eastern to central Pacific in some decades (e.g., before 1976/77) but from central to eastern Pacific in the other decades (e.g., after 1976/77).

This view is used to explain the excessive biennial tendency in the NCAR CCSM3's ENSO simulations. We argue that because the CCSM can not produce the annual cycle of the eastern Pacific cold tongue, this model can not produce the eastern Pacific oscillator. In stead, the ENSO cycle produce by the CCSM is dominated by the western Pacific oscillator. In the CCSM, this oscillator is over sensitive to the forcing from Indian monsoon and becomes too strong in the biennial timescale. Based on our view, the excessive biennial ENSO tendency in the CCSM is a separate issue from the lack of a low-frequency (~4 years) component of ENSO in the model. Reducing the biennial ENSO does not necessary lead to the production of a stronger 4 year ENSO. The lack of the 4-year ENSO component is tied to the model performance of cold tongue simulation. The excessive 2-year ENSO component is tied to the model performance of monsoon simulation.

Evidences from observational analyses and CCSM experiments will be presented to support our view.

Dissecting Tropical Biases in the NCAR CAM3 and CCSM3

Primary Author: Zhang, Guang

This study investigates two tropical biases in the NCAR CAM3 and its coupled model simulations: lack of shortwave cloud radiative forcing response to ENSO and double ITCZ. By contrasting the simulations with different versions of the Zhang-McFarlane convection parameterization and model resolutions, we will identify the causes of the biases, and provide suggestions to remedy the existing model deficiencies.

Diurnal Cycle of Convection, Clouds and Upper Troposphere Humidity

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Multi-scale Modeling Framework (MMF) is a new approach in which the conventional cloud parameterization in global climate models is substituted by the cloud resolving models, thus cloud related dynamical, physical and chemical processes can be represented on their native scale. 3-hourly global data for three boreal summer months are collected from MMF simulations. Brightness temperatures (6.7 and 11 micrometer) are simulated based on the MMF cloud microphysics, surface properties and the atmospheric vertical structures of temperature, humidity and ozone. Diurnal cycles of precipitation, clouds and upper troposphere humidity are retrieved from the brightness temperatures. Diurnal composites for tropical land and ocean area are constructed and compared to the available satellite data (Tian et al, 2004). Diurnal composites for nocturnal precipitating, daytime precipitating and clear days are constructed over the ARM SGP site and compared to the ARM continuous forcing data. By doing so, we hope to give an assessment on the diurnal cycle in the MMF and contribute to the improvement of the representation of convection in conventional climate models.

Arctic Sea Ice Simulations and Projections by the IPCC AR4 Climate Models: Credibility and Systematic Bias

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Arctic Sea Ice Simulations and Projections by the IPCC AR4
Climate Models: Credibility and Systematic Bias

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Arctic sea ice is a contributing and responding component to global climate change, which impact global energy balance and may amplify global warming signal. Export of Arctic sea ice through Fram Strait and the Canadian Archipelago may also weaken the North Atlantic deep convection and have significant implications for multidecadal climate variability and even paleoclimatic event. The recent IPCC AR4 climate models provide comprehensive simulations of various aspects of the Arctic sea ice. In these models, sea ice dynamics and thermodynamics were generally much improved with various complexities, compared with their previous versions. Although we have gained some credibility in projections of the Arctic sea ice changes in the 21st century through multi-model ensemble mean approach, our published results (Zhang and Walsh 2006) still show a large diversity across-models and across-mode-ensemble-members. Some systematic biases, for example the overestimated sea ice coverage over the Barents Sea, exist in most models. In this study, we aim to gain a deep insight into the models credibility and systematic biases in the simulations of the Arctic sea ice through analyzing climate state and changes of each category of sea ice and by comparing model simulations with the updated satellite sea ice data up to 2006. The results would provide useful information for model improvements and for improving understanding of assessment of Arctic sea ice changes in future.

Simulations of the Madden-Julian Oscillation in Four Pairs of Coupled and Uncoupled Global Models

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Simulations of the Madden-Julian Oscillation in Four Pairs of Coupled and Uncoupled Global Models

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The status of the numerical reproduction of the Madden-Julian Oscillation (MJO) by current global models was assessed through diagnoses of four pairs of coupled and uncoupled simulations. Slow eastward propagation of the MJO, especially in low-level zonal wind, is realistic in all these simulations. However, the simulated MJO suffers from several common problems. The MJO signal in precipitation is generally too weak and often eroded by an unrealistic split of an equatorial maximum of precipitation into a double ITCZ structure over the western Pacific. The MJO signal in low-level zonal wind, on the other hand, is sometimes too strong over the eastern Pacific but too weak over the Indian Ocean. The observed phase relationship between precipitation and low level zonal wind associated with the MJO in the western Pacific and their coherence in general are not reproduced by the models. The seasonal migration in latitude of MJO activity is missing in most simulations. Air-sea coupling generally strengthens the simulated eastward propagating signal, but its effects on the phase relationship and coherence between precipitation and low-level zonal wind, and on their geographic distributions, seasonal cycles, and interannual variability are inconsistent among the simulations. Such inconsistency cautions generalization of results from MJO simulations using a single model. In comparison to observations, biases in the simulated MJO appear to be related to biases in the background state of mean precipitation, low-level zonal wind, and boundary-layer moisture convergence. This study concludes that, while the realistic simulations of the eastward propagation of the MJO are encouraging, reproducing other fundamental features of the MJO by current global models remains an unmet challenge.

The 20th Century East Asian Summer Monsoon Simulated by Coupled Climate Models of IPCC AR4

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The 20th Century East Asian Summer Monsoon Simulated by Coupled Climate Models of IPCC AR4

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East Asian monsoon climate exhibits variability on many time scales. While the interannual variations of the monsoon are well documented, the East Asian monsoon also shows large interdecadal variations during the last 50 years or so, and this longer-term variability is poorly understood. Here we analyze the outputs of the 20th century climate simulations (20C3M) by 23 coupled climate models involved in IPCC AR4 to evaluate the performance of the latest generation of climate models in simulating the present climate over East Asia, and to address the question of whether the prescribed external forcing agents have played key roles in producing the interdecadal variability of the East Asian summer monsoon (EASM). The results show that only models employing a high resolution AGCM component have reasonable performances in producing the main monsoon circulations such as the East Asian westerly jet, the western Pacific subtropical high and the low level monsoon circulations. The decadal variations of the EASM in ten models have significant correlations with observations during 1880-1999. For the recent half century (1950-1999), the EASM indices of nine models are significantly correlated with the observations at time scales longer than 10 years. These nine models include the CCSM3, CGCM3.1(T47), GFDL-CM2.0, GFDL-CM2.1, GISS-AOM, GISS-ER, INM-CM3.0, IPSL-CM4, UKMO-HadGEM1. Starting from late 1970s, the EASM has experienced a strong weakening trend in observations, which resulted in less rainfall along the mid-lower Yellow River valley and excessive rainfall along the Yangtze River valley. This anomalous rainfall pattern is usually referred to as the Southern Flooding and Northern Drought (SFND). Our analyses show that only a small number of models, namely the GFDL-CM2.1, IPSL-CM4, and HadCM3, have successfully produced this weakening trend of the EASM. Furthermore, the weakening trend of the EASM in GFDL-CM2.1 is shown to be a forced-signal rather than model internal variability. Future work needs to separate the natural and anthropogenic forcing agents in climate model simulations and address the relative contributions of natural and anthropogenic forcings to the recent weakening of the EASM.

Key word: East Asian summer monsoon, coupled model, decadal variability